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Presented in (input and Bold one): (**WG10**, CG____, Special Session ____, Poster, Demo, or Tutorial):

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Generating Enhanced Natural Environments & Terrain for Interactive Combat Simulations (GENETICS)



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GENETICS Project Overview



- Automatically construct realistic, vegetation-laden terrain using a minimum amount of readily-available source data, adding plausible details as needed.
- This procedurally-created terrain must be replicable across a wide variety of simulation platforms, creating a consistent virtual world without any terrain databases being shared.

So why focus on vegetation?

(and why should you care?)



- Adds believability to the environment
 - Trees are in our environment... why not in our sims?
- Visual cues needed to perform tasks:
 - Depth cues – e.g. “What’s my altitude?”
 - Speed cues – e.g. “How fast am I going?”
 - Landmarks – e.g. “I’m next to the big tree in the field.”
- Makes target acquisition non-trivial



So why focus on vegetation?

(and why should you care?)

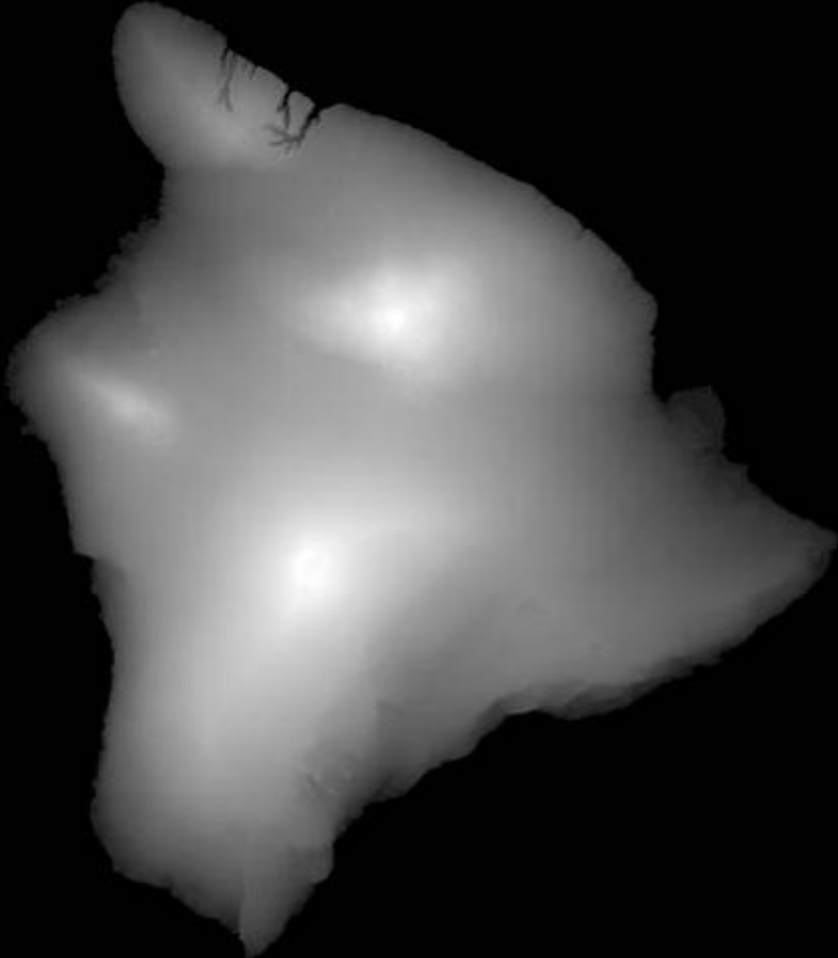


- Adds believability to the environment
 - Trees are in our environment... why not in our VEs?
- Visual cues needed to perform tasks
 - Depth cues – e.g. “What’s my altitude?”
 - Speed cues – e.g. “How fast am I going?”
 - Landmarks – e.g. “I’m next to the big tree in the field.”
- Makes target acquisition non-trivial

But mainly because...

- Many consider this a “too hard to do” problem
 - Want proof? Look at today’s simulator environments...

Find source data

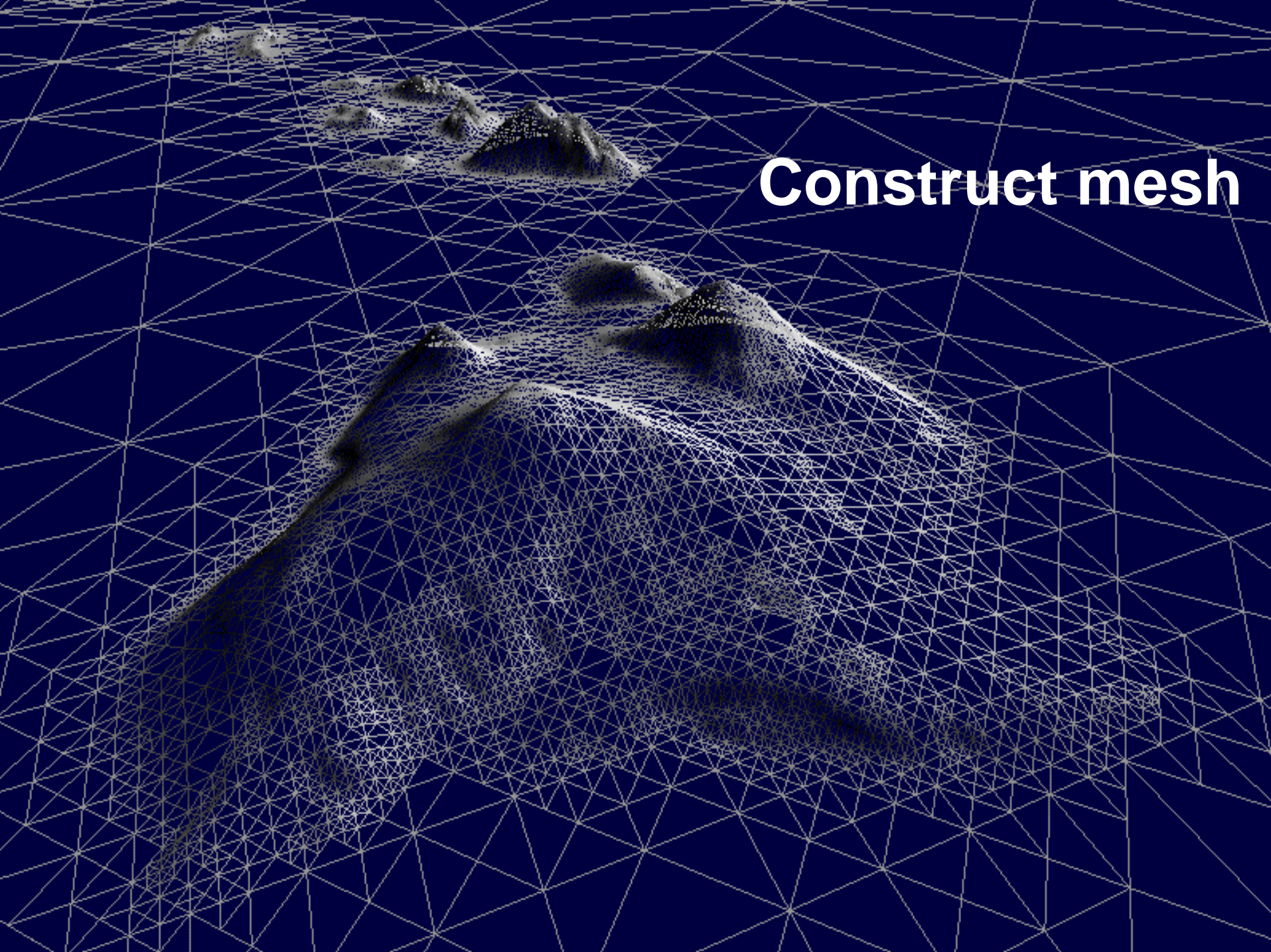


Heightmap

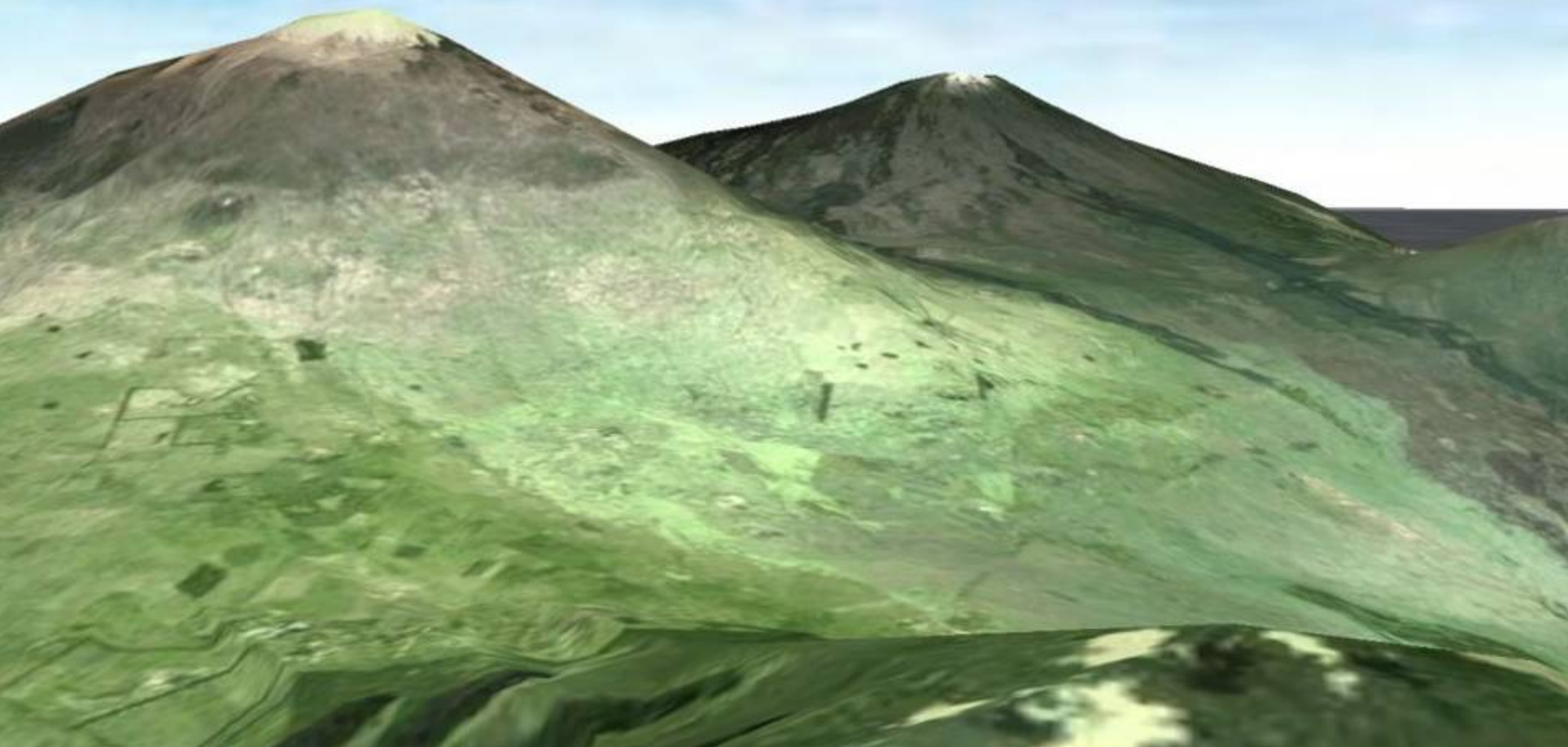


Imagery

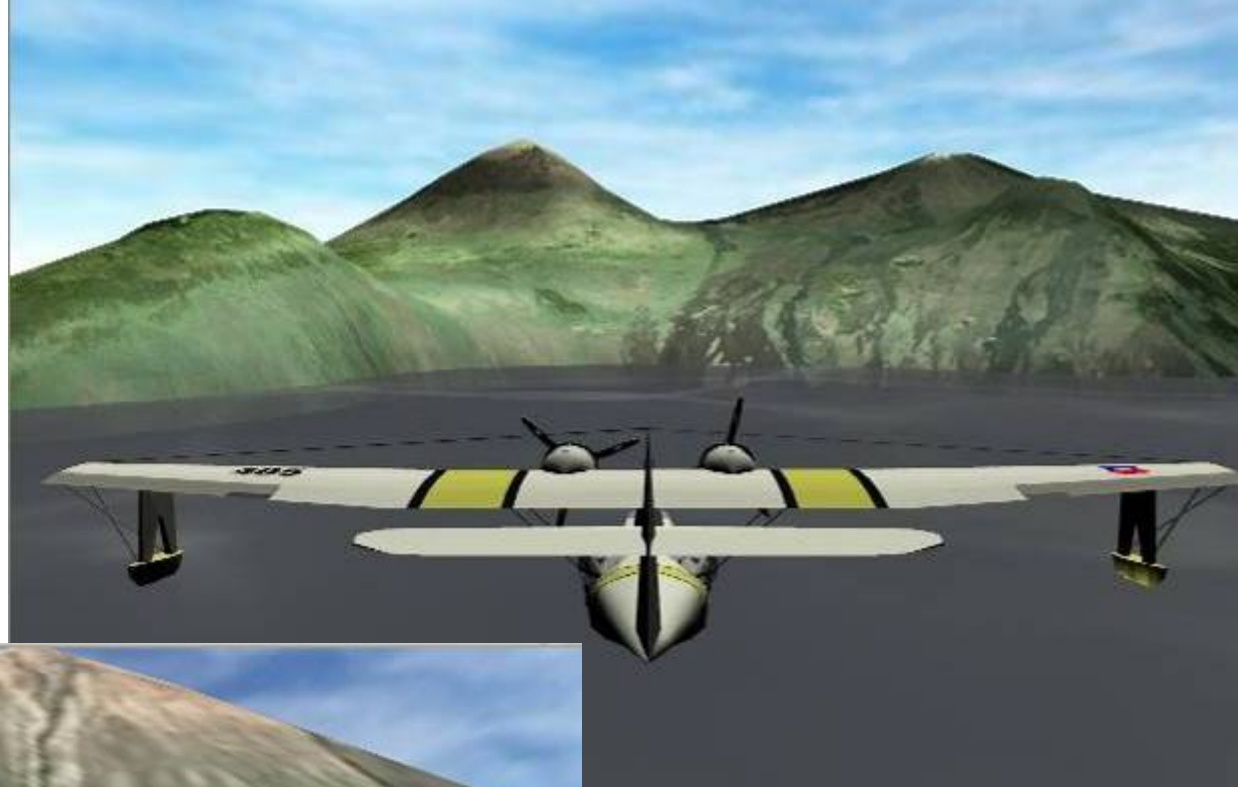
Construct mesh



Drape imagery over mesh



**Insert player
& add details**



**Catalina demo
MOVES Open House 2003**

What terrain looks like today



- Quick to create, large and barren





What terrain looks like today



- Quick to create, large and barren

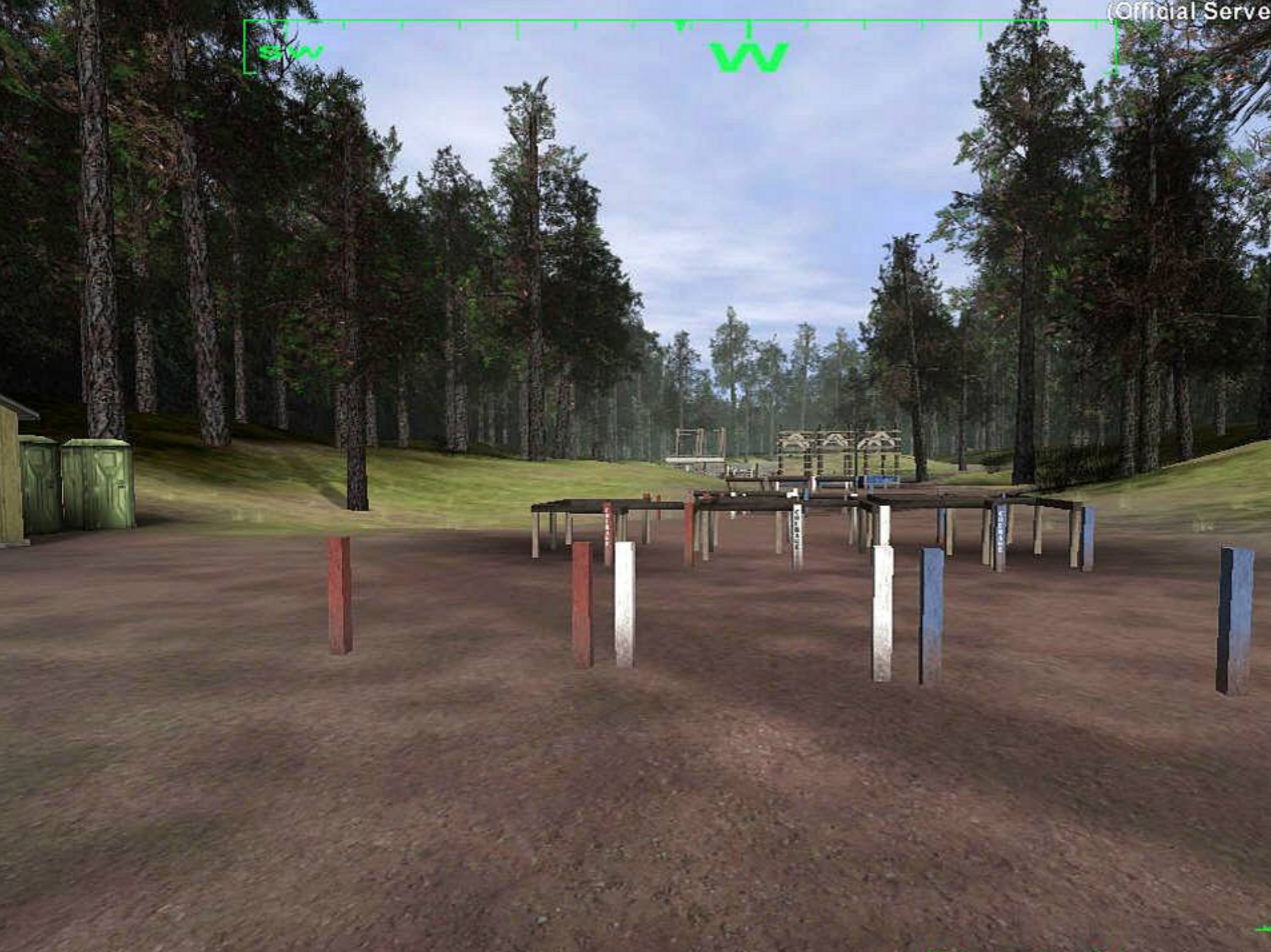
or

- Slow to create, small and gorgeous

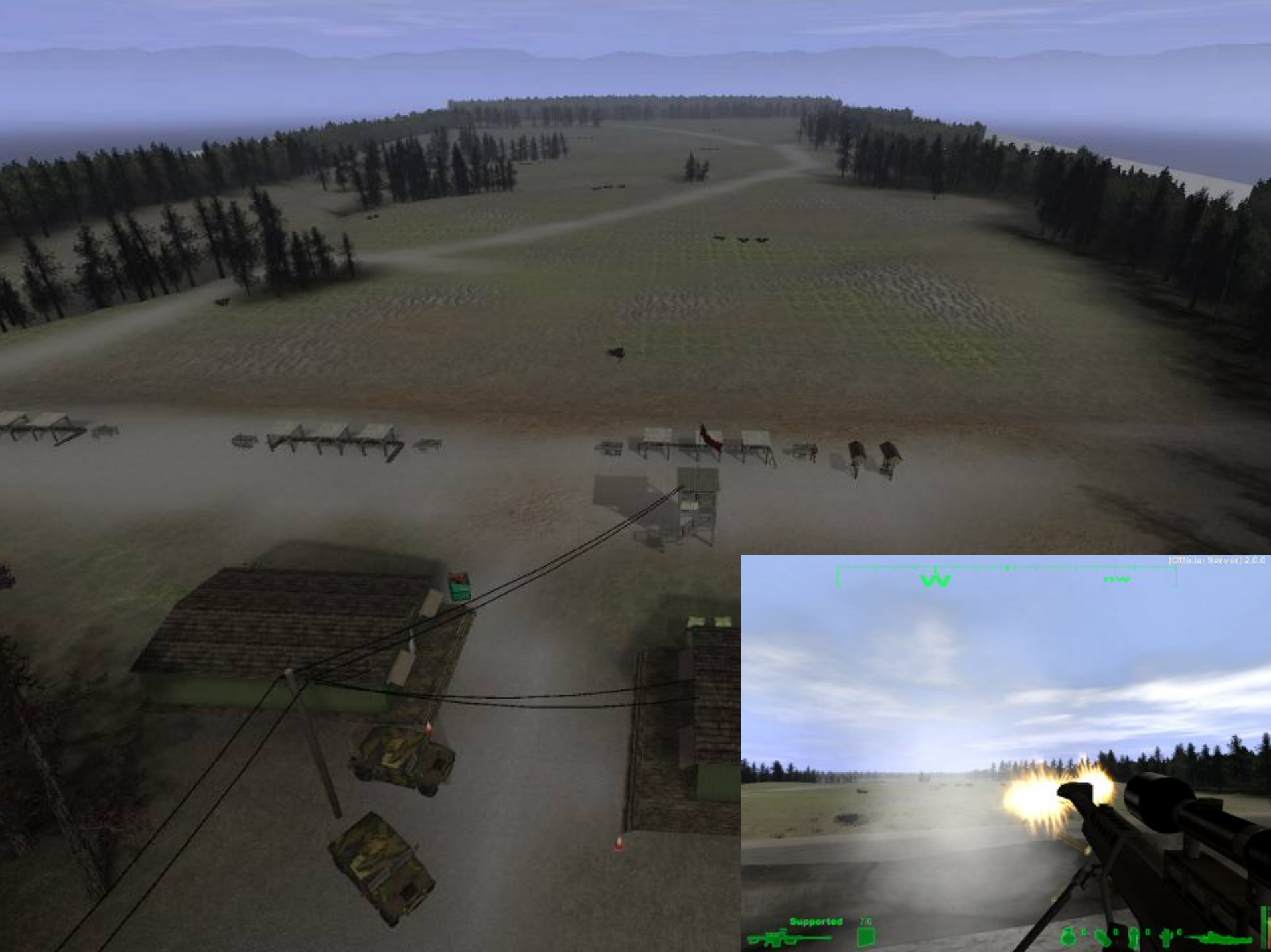


SW

W









Hasn't this been done before?



- The problem with vectorized datasets...
 - VMAP/DFAD – based on 1:250K JOGs (CE ~ 125m)
 - LULC – based on 1:100K/250K quads from 70s & 80s
 - Minimum vegetation area ~ 40 acres
 - *NLCD 1992 uses 30m postings; min area ~ .25 acres*

topozone

Copyright 1999-2003 Maps a la carte, Inc.

SAN JUAN

ROAD

33

38

50

BM 40

57

BM 34

BM 39

BM 62

1:24K

D E S A N C A Y E T A N O

ROAD

VEGA

305

200

200

400

300

100

200

14

305

Corneob

Canyon

LEWIS

ROAD

305

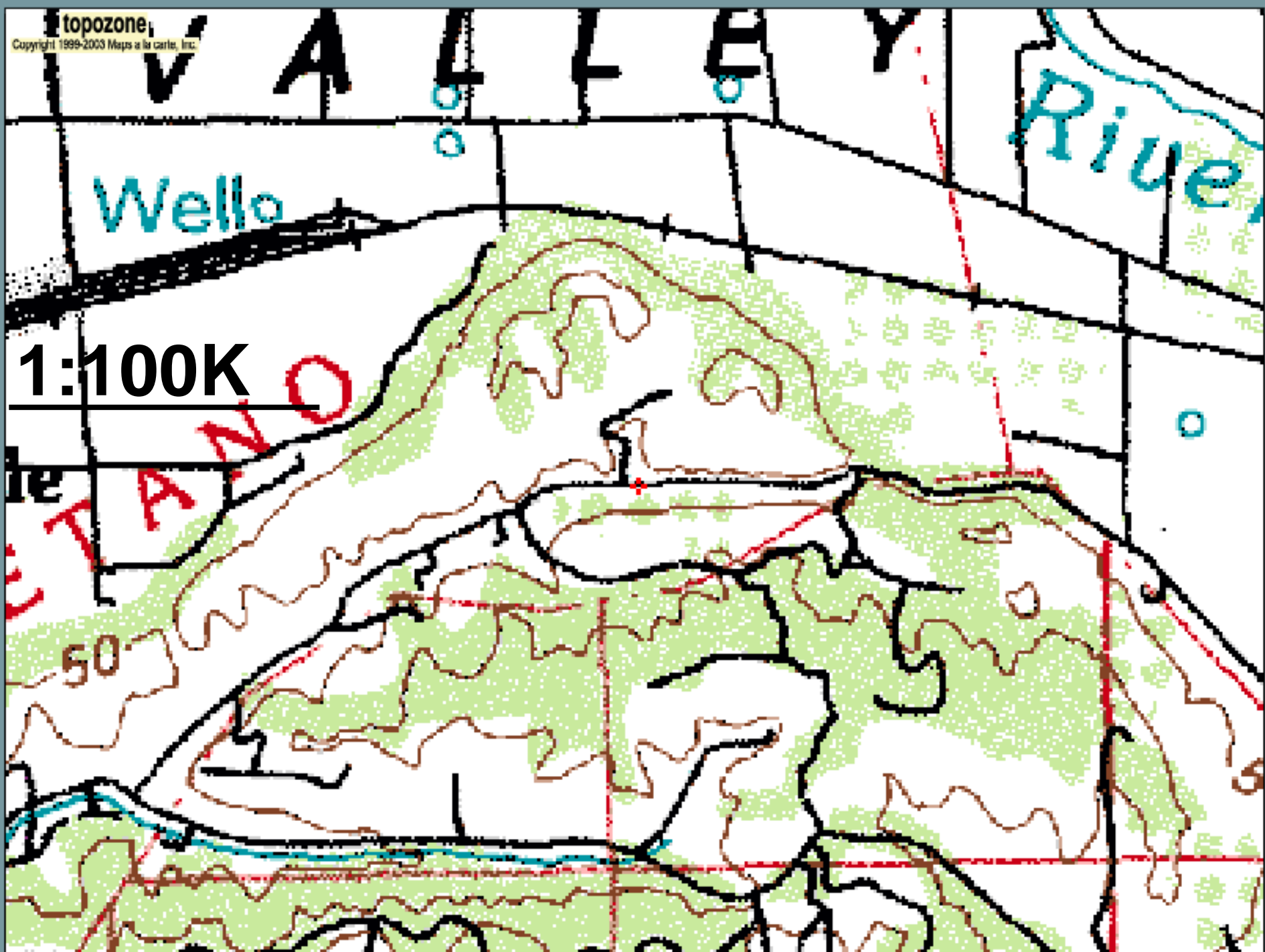
18

19

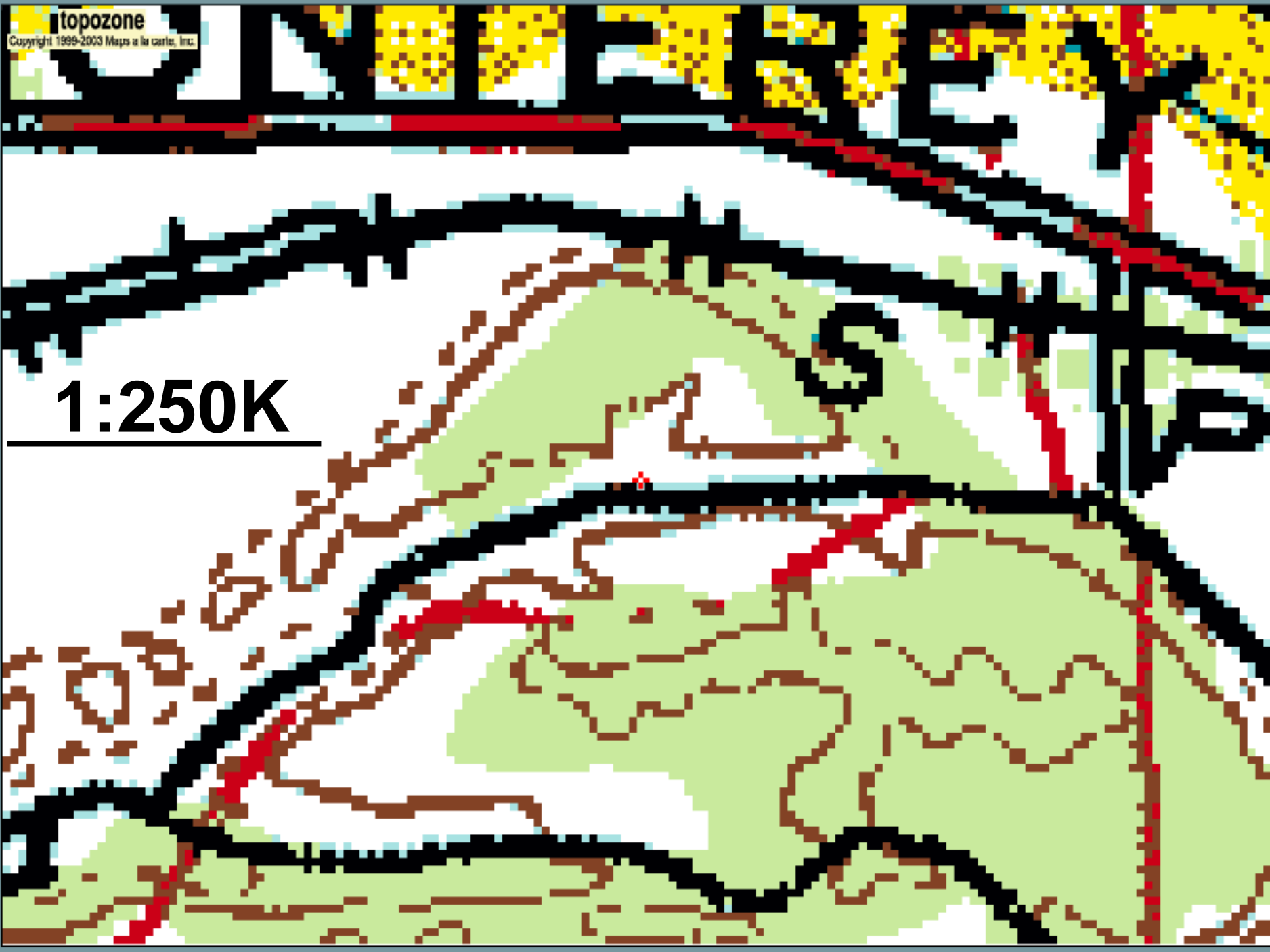
Well

SAN

MIGUEL



1:250K

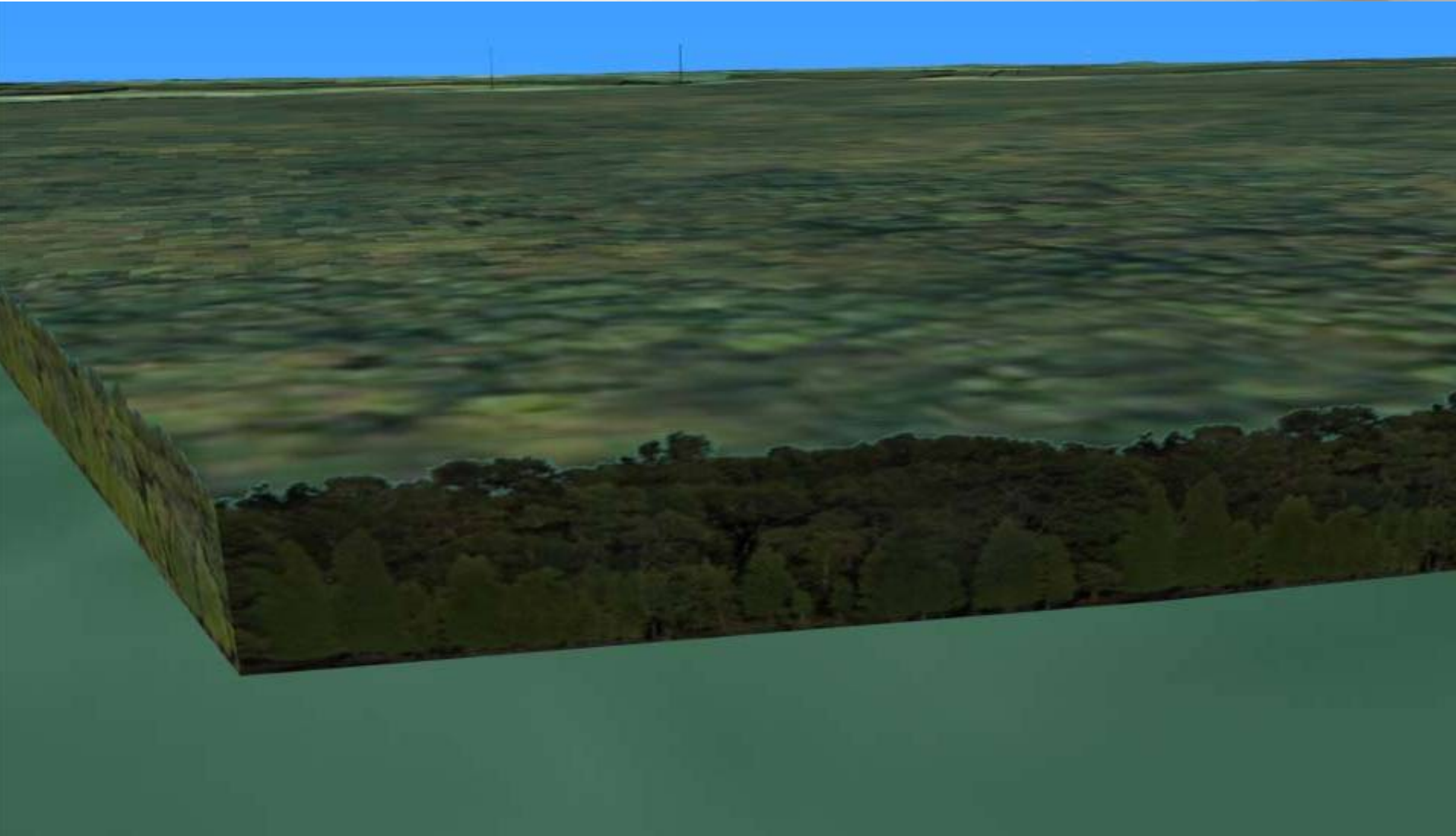


Hasn't this been done before?

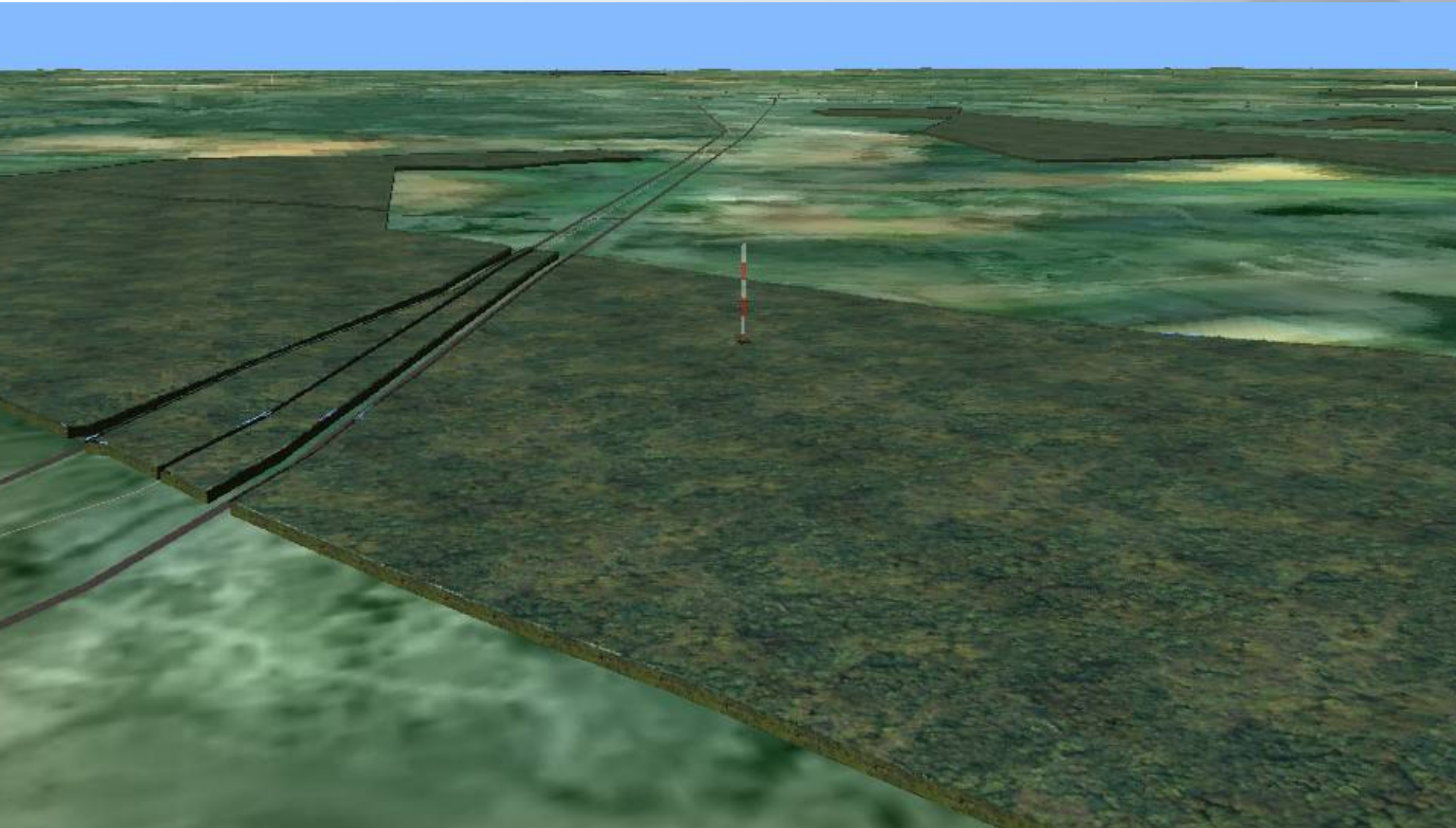


- The problem with vectorized datasets...
 - VMAP/DFAD – based on 1:250K JOGs (CE ~ 125m)
 - LULC – based on 1:100K/250K quads from 70s & 80s
 - Minimum area ~ 40 acres
 - *NLCD 1992 uses 30m postings; min area ~ .25 acres*
- Commercial tools & vectorized datasets
 - Tree walls/buildings and random placement

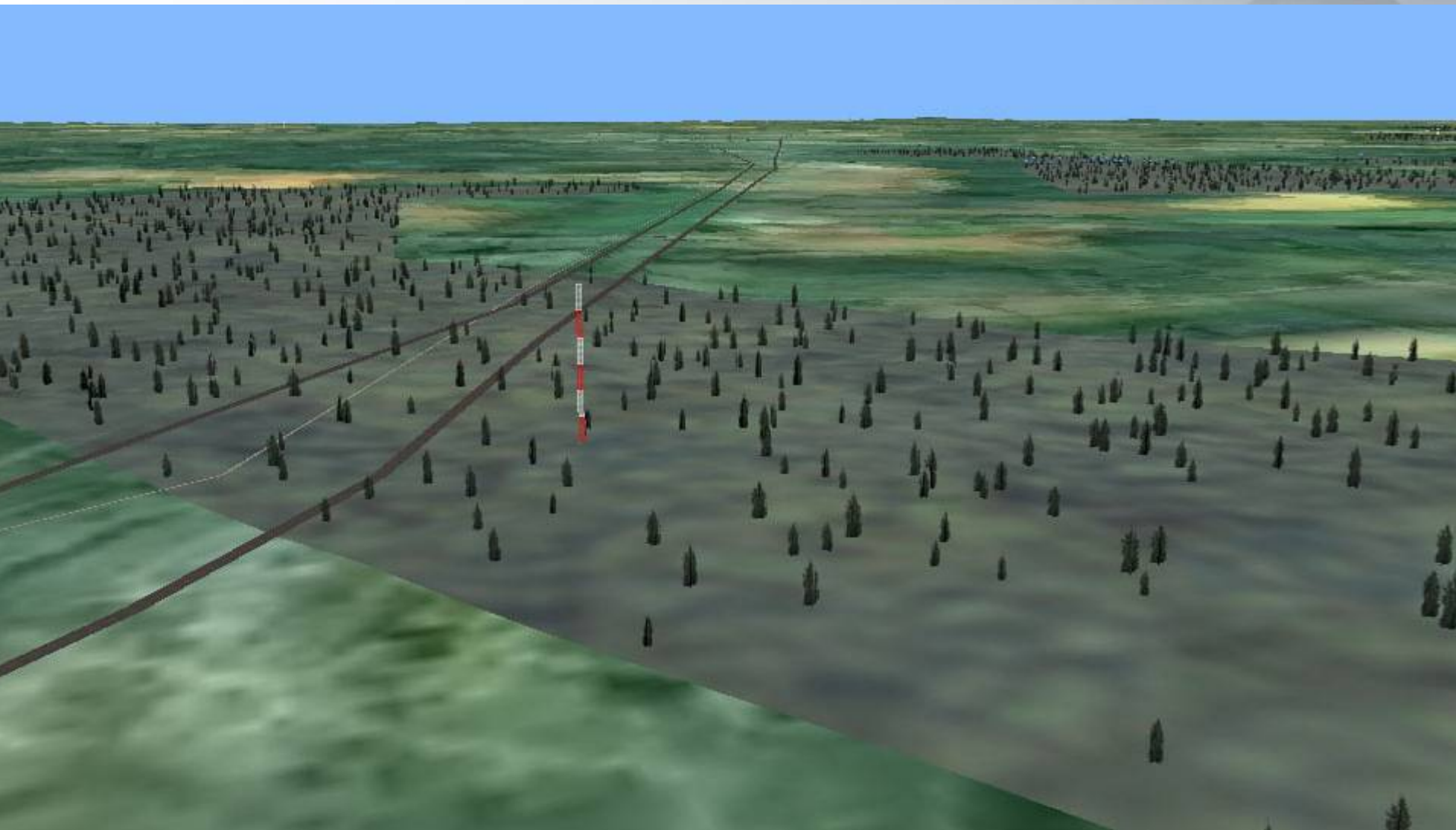
Tree blocks



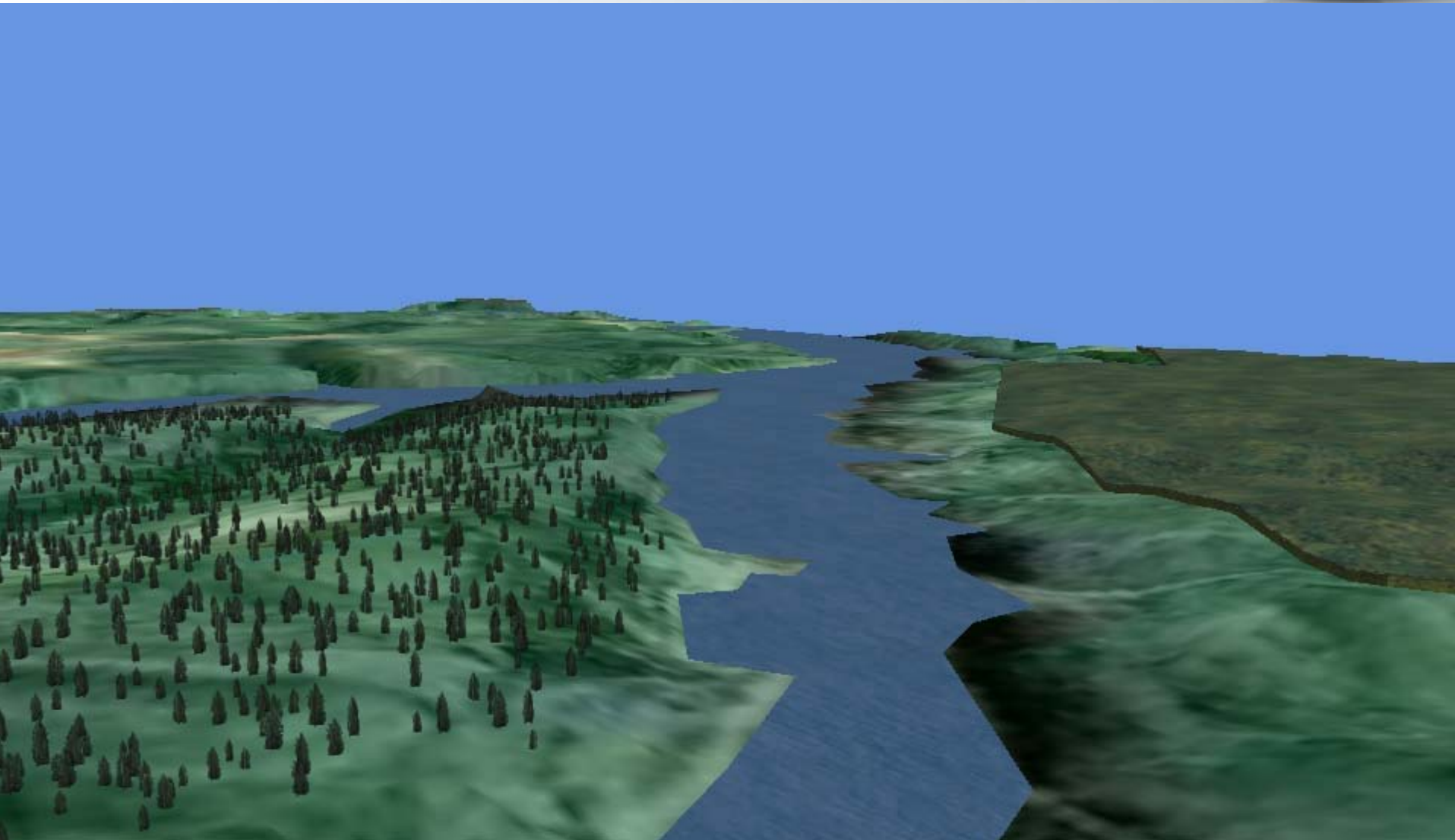
Tree blocks



Random placement



Tree blocks vs. random placement



Hasn't this been done before?



- Vectorized datasets
 - VMAP/DFAD – based on 1:250K maps (CEP ~ 125m)
 - LULC – based on 1:100K/250K quads from 70s & 80s
 - Minimum rural area ~ 40 acres
 - *NLCD 1992 uses 30m postings; min area < .25 acre*
- Commercial tools and vectorized datasets
 - Tree walls/buildings and random placement
 - Ex: \$35K + \$6K annual maintenance + \$5K in training
 - Time to construct: hours, days, weeks (dep. artist skill)
- Semi-automated feature extraction
 - Requires very high resolution imagery (~6 in)

“Semi-Automated Landscape Feature Extraction and Modeling” - Wasilewski et al. 2001



Training

input image



user-created mask

Automation



Partition imagery,
Filtering/smoothing,
Detection,
Thinning of blobs,
Maxima detection,
Overlapping trees,
Final tree placement



Recipe for GENETICS



- Take readily available source data (DTED, LCC, imagery)
- Set configuration params (RN seed, veg density & resolution)
- Generate:
 - Increased resolution of terrain mesh using noise
 - High frequency detail maps mixed with imagery or procedurally-created geotypical base textures
 - Ecotype probability map based on LCC & topographic data to establish type and frequency/density of vegetation
 - Randomly place vegetation based on above params
- Different seeds will generate similar, but different scenes
- Using same seed across hosts creates perceptibly the same landscape depending on the player's LOD requirements
- Missing data can be created using fractal-based techniques

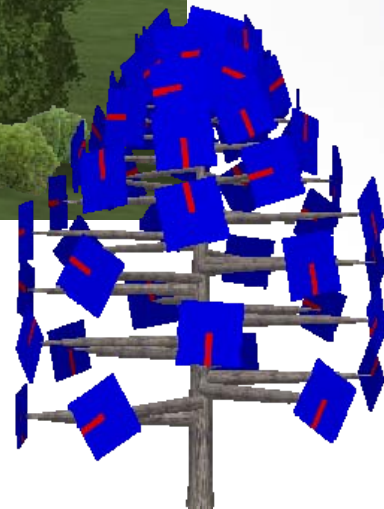
What about vegetation rendering?



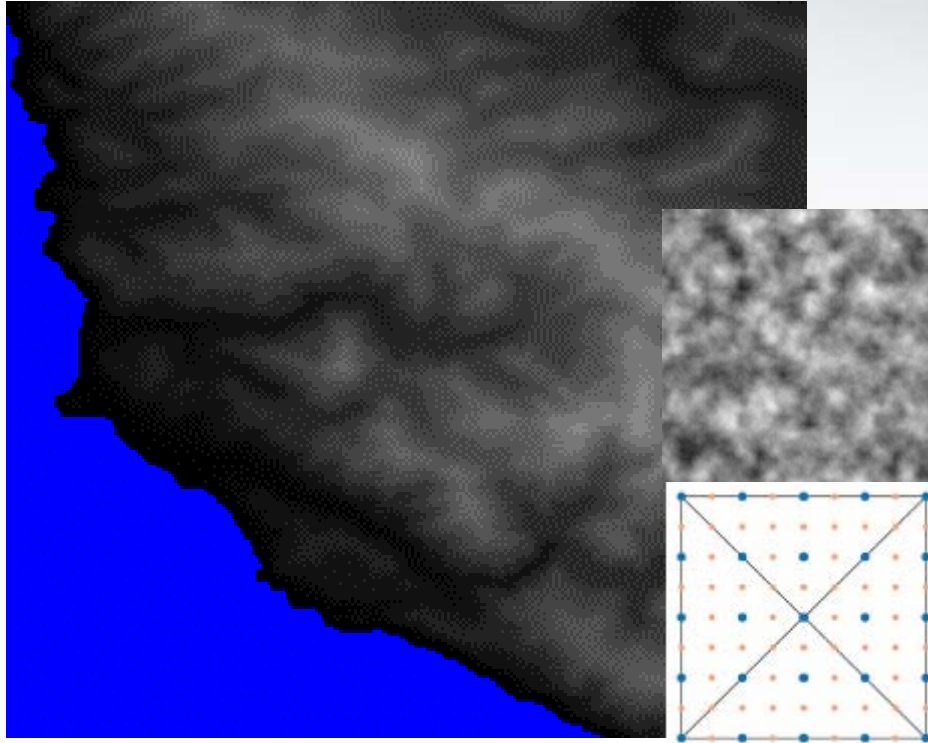
- Geometry
- Billboards
- Imposters
- Point & line clouds
- Combo of the above
- **Or use a commercial package (we do)**



- **Place in quadtree hierarchy**
- **LOD individual objects and object groups**



Our source data



- **DTED 0, 1, 2 or USGS DEM**
- Add multi-fractal high freq noise
- Continuous level of detail scheme to reduce mesh complexity
- Derive topographic features/images

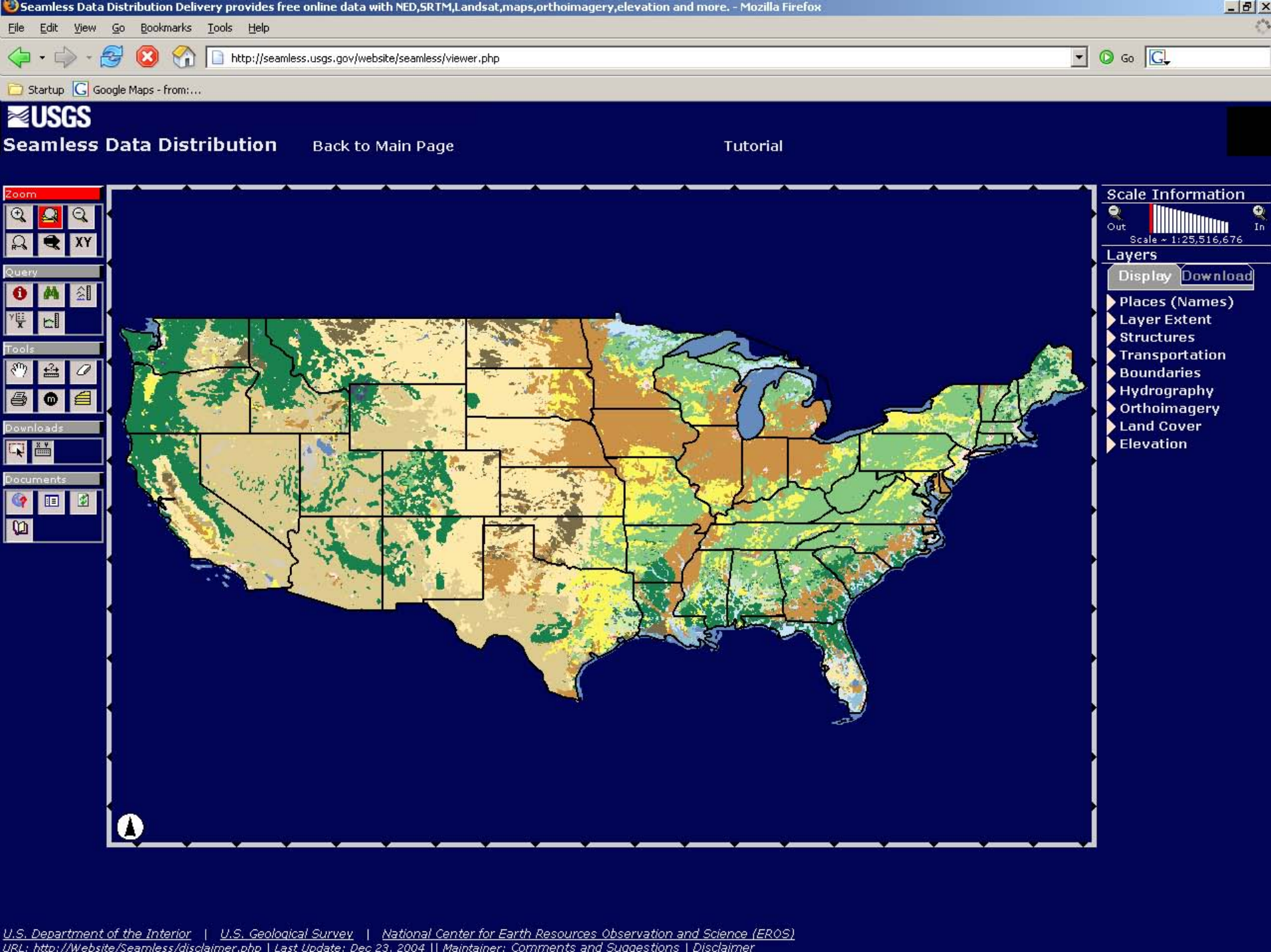


- **Land cover classification dataset**
- NLCD 1992, CORINE 2000, etc.
- GeoTIFF color-mapped images
- Obtain each LCC type's points and smooth to overlap types

National Land Cover Dataset 1992




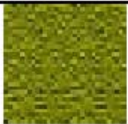

(downloadable from <http://seamless.usgs.gov/>)



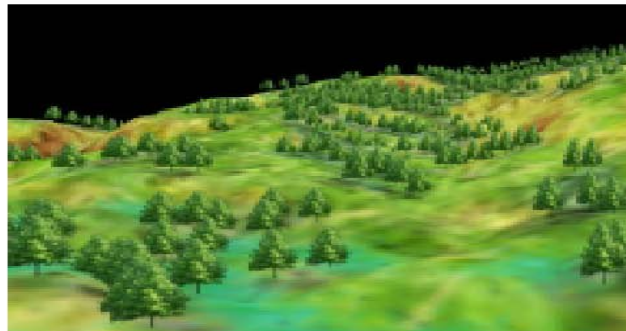
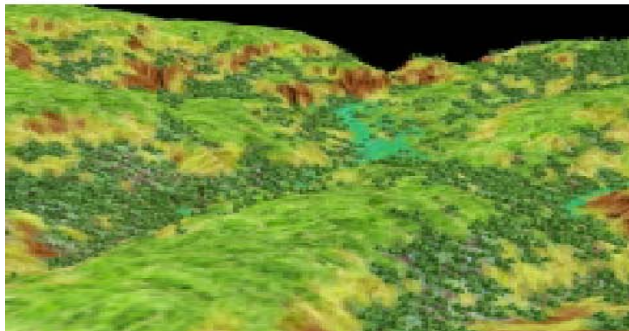
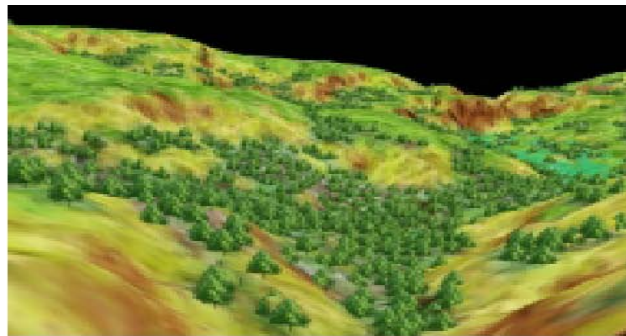
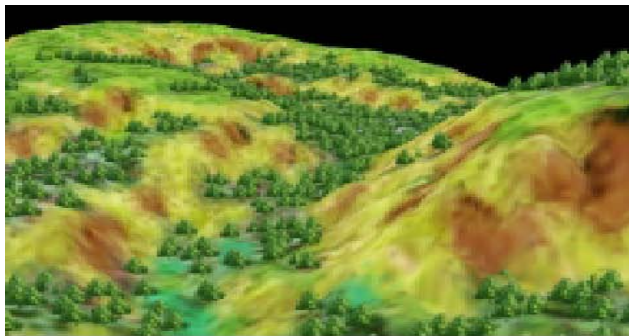
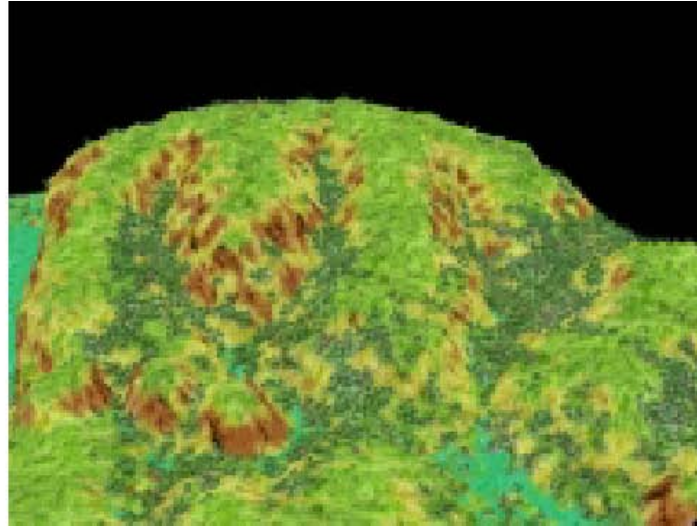
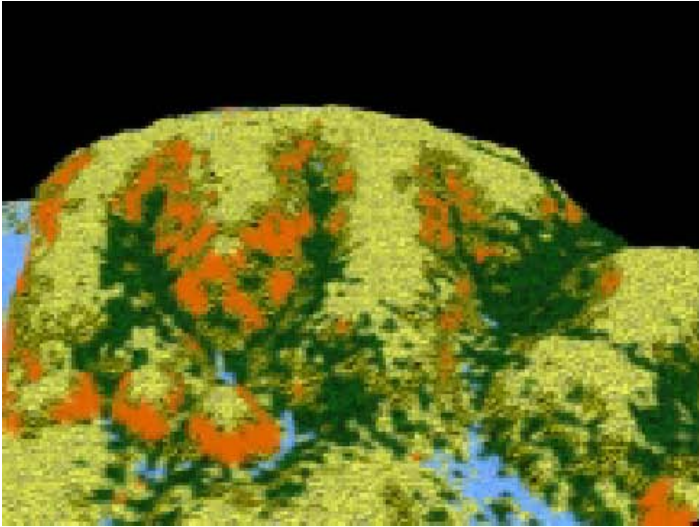


“Modeling of ecosystems as a data source for real-time terrain rendering” (Hammes, 2001)



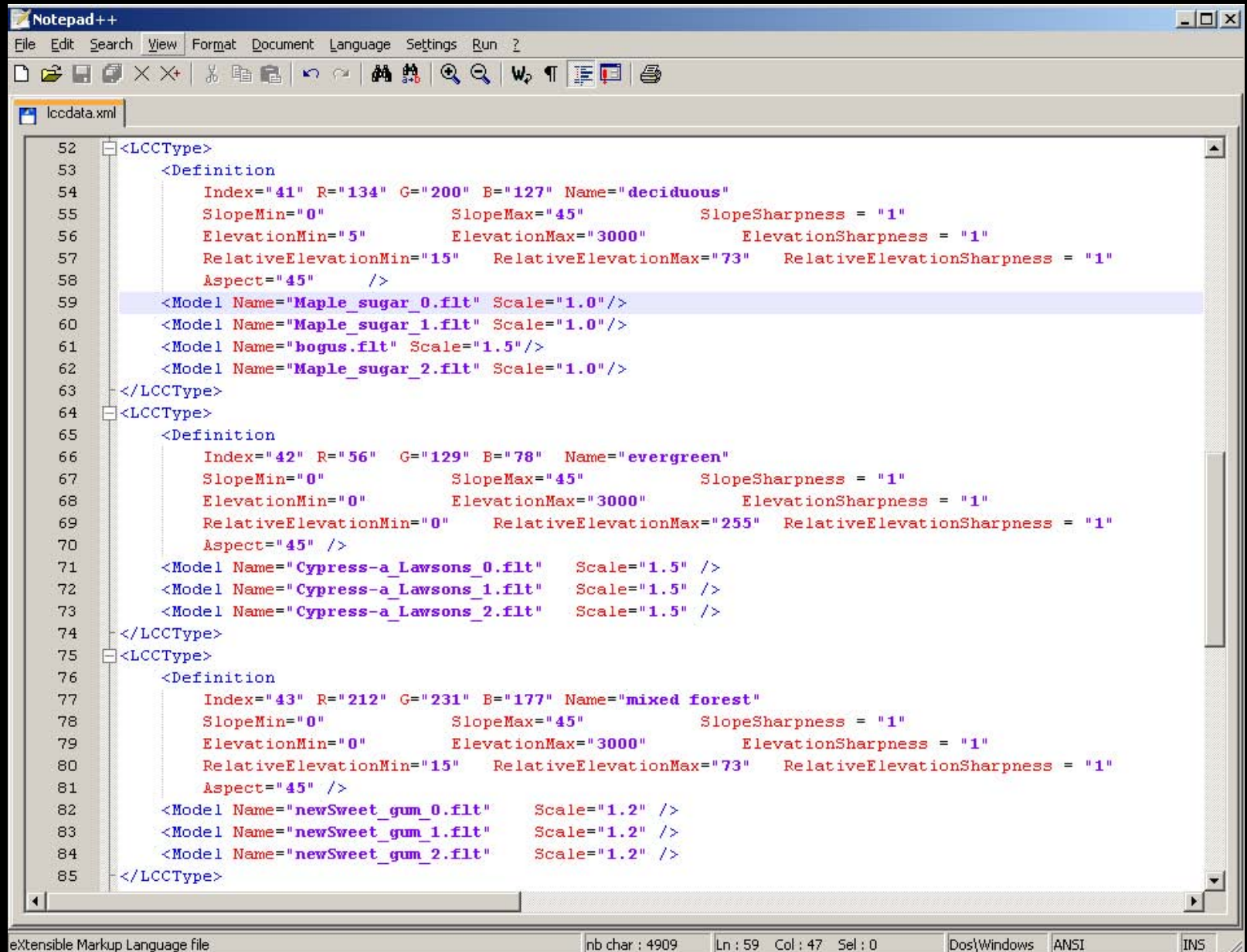
Ecosystem	Color		Elevation	Relative elevation	Slope
Dense bush		Min Max Sharpness	140 260 2	-0.5 0.1 1	0.0 0.7 2
Marshland		Min Max Sharpness	-50 50 2	-0.5 0 1	-0.2 0.3 2
Small bushes and grass		Min Max Sharpness	-50 350 2	0.07 0.3 1	-0.2 0.8 2
Grass on steep slopes		Min Max Sharpness	-50 350 2	0 1 1	0.7 1.2 2
Exposed rock		Min Max Sharpness	-50 350 2	-1 1 1	1.4 4.2 8

Modeling Ecosystems (Hammes, 2001)



- 5 ecotypes
- 1 plant model
- Elevation-based
- No effort to match to actual LCC data

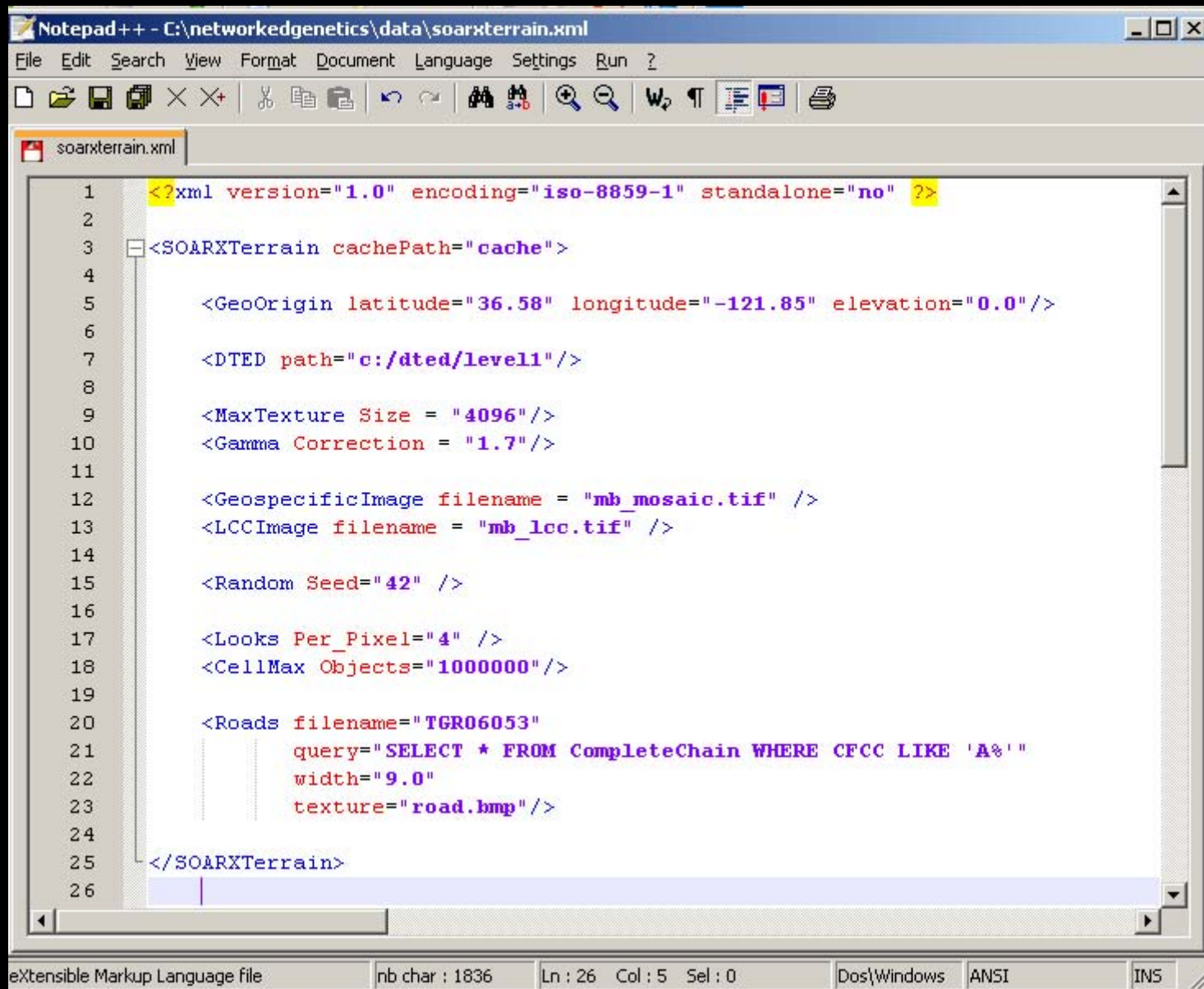
How we define ecotypes



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70     Aspect="45" />
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72   <Model Name="Cypress-a_Lawsons_1.flt" Scale="1.5" />
73   <Model Name="Cypress-a_Lawsons_2.flt" Scale="1.5" />
74 </LCCType>
75 <LCCType>
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Our system configuration file
























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15    <Random Seed="42" />
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17    <Looks Per_Pixel="4" />
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22        width="9.0"
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25 </SOARXTerrain>
26
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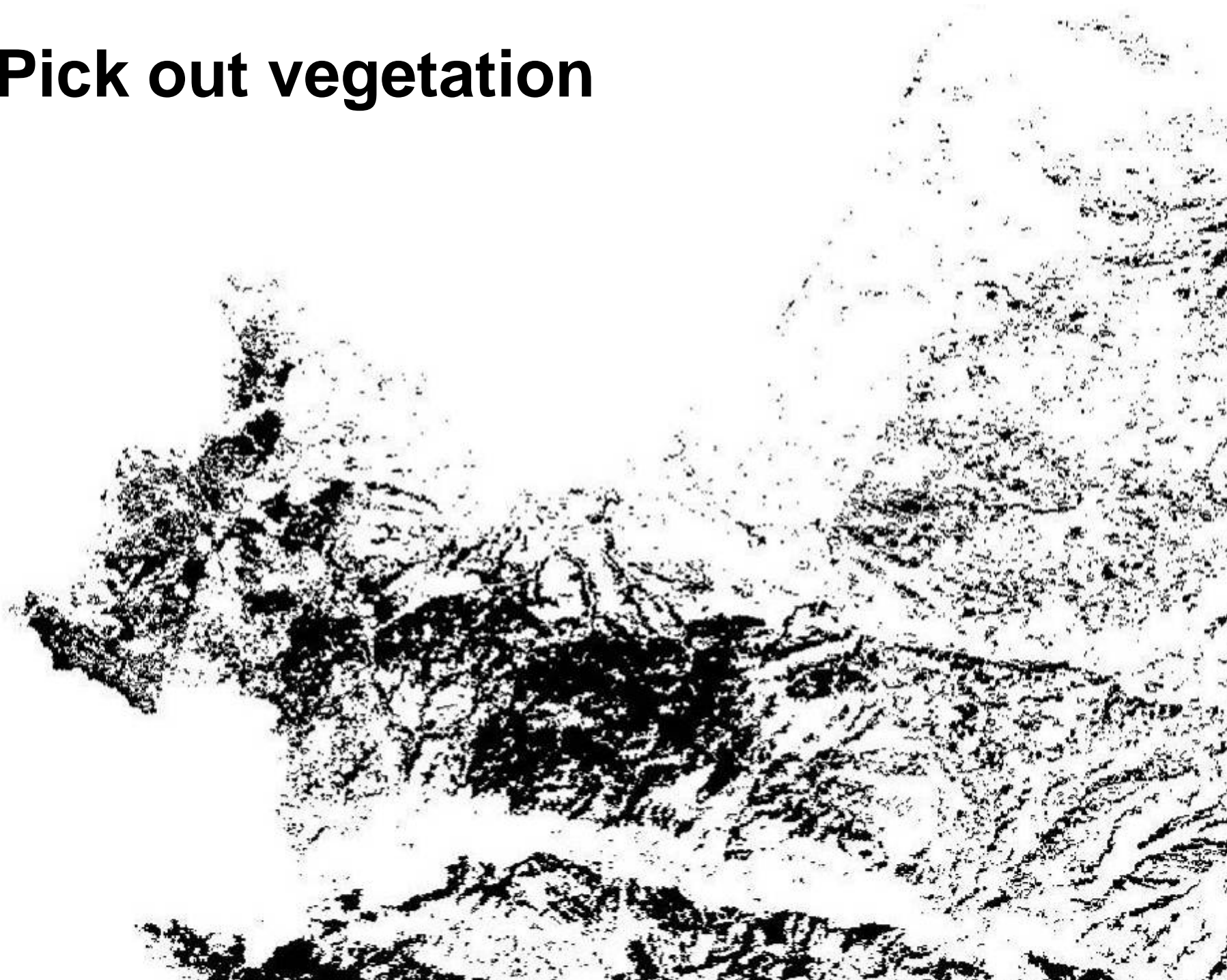
Land Cover Classification



National Land Cover Dataset Classification System Legend

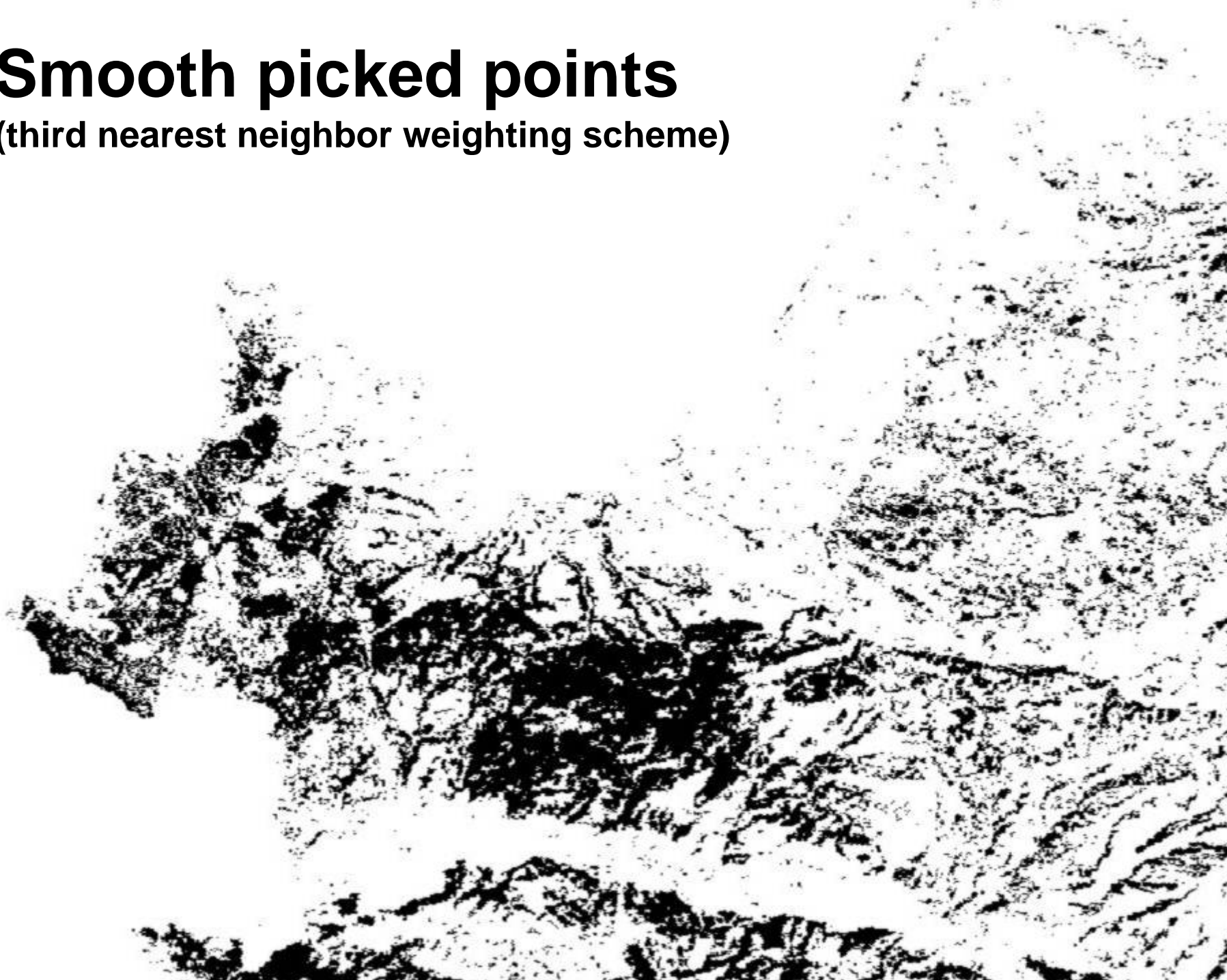
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	102, 140, 190	11 - Open Water
	255,255,255	12 - Perennial Ice/Snow
	253, 229, 228	21 - Low Intensity Residential
	247, 178, 159	22 - High Intensity Residential
	231, 86, 78	23 - Commerical/Industrial/Transportation
	210, 205, 192	31 - Bare Rock/Sand/Clay
	175, 175, 177	32 - Quarries/Strip Mines, Gravel Pits
	83, 62, 118	33 - Transitional
	134, 200, 127	41 - Deciduous Forest
	26, 129, 78	42 - Evergreen Forest
	212, 231, 177	43 - Mixed Forest
	220, 202, 143	51 - Shrubland
	187, 174, 118	61 - Orchards/Vineyards
	253, 233, 170	71 - Grasslands/Herbaceous
	252, 246, 93	81 - Pasture/Hay
	202, 145, 71	82 - Row Crops
	121, 108, 75	83 - Small Grains
	244, 238, 203	84 - Fallow
	240, 156, 054	85 - Urban/Recreational Grasses
	201, 230, 249	91 - Woody Wetlands
	144, 192, 217	92 - Emergent Herbaceous Wetlands

Pick out vegetation

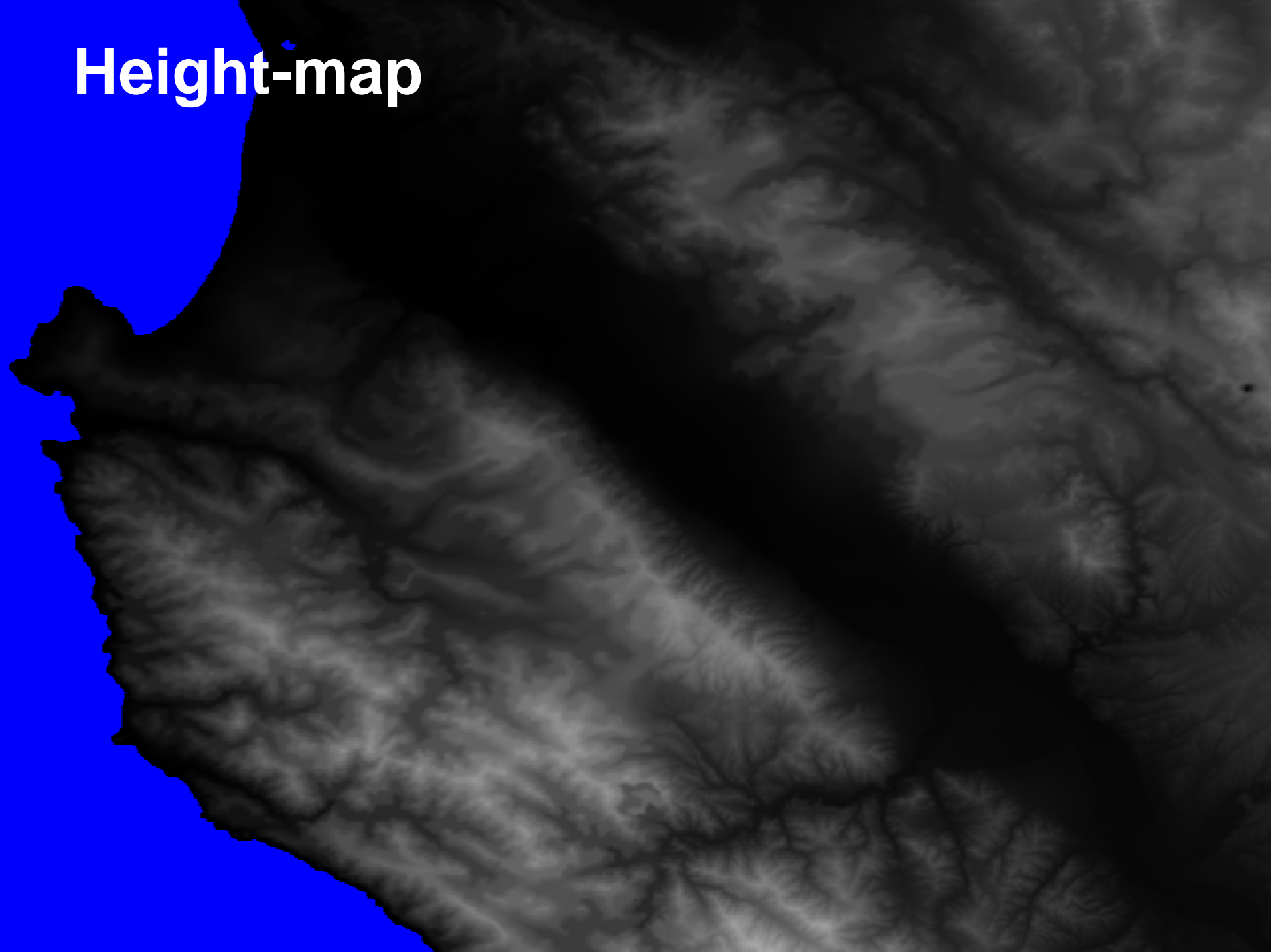


Smooth picked points

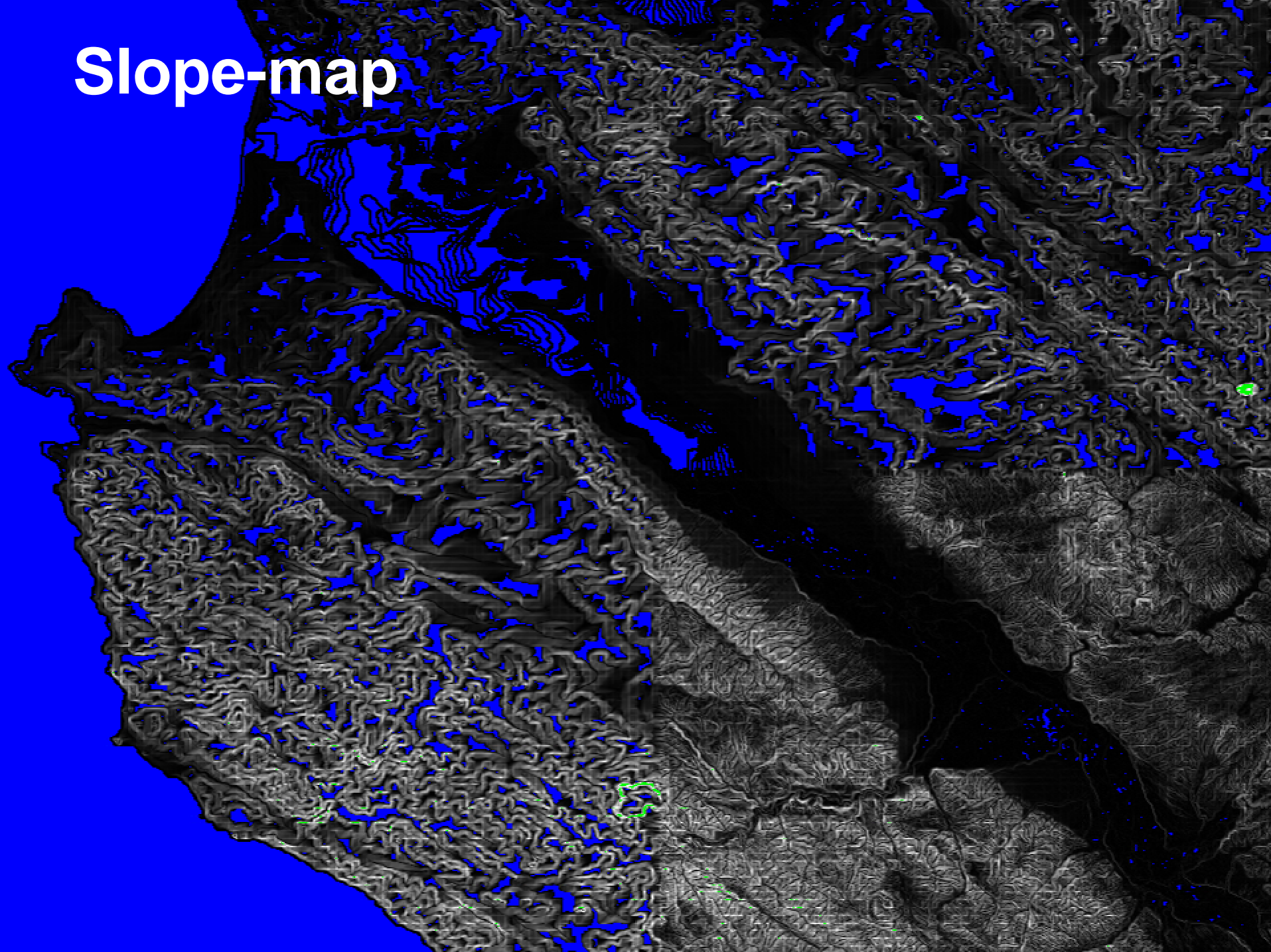
(third nearest neighbor weighting scheme)



Height-map

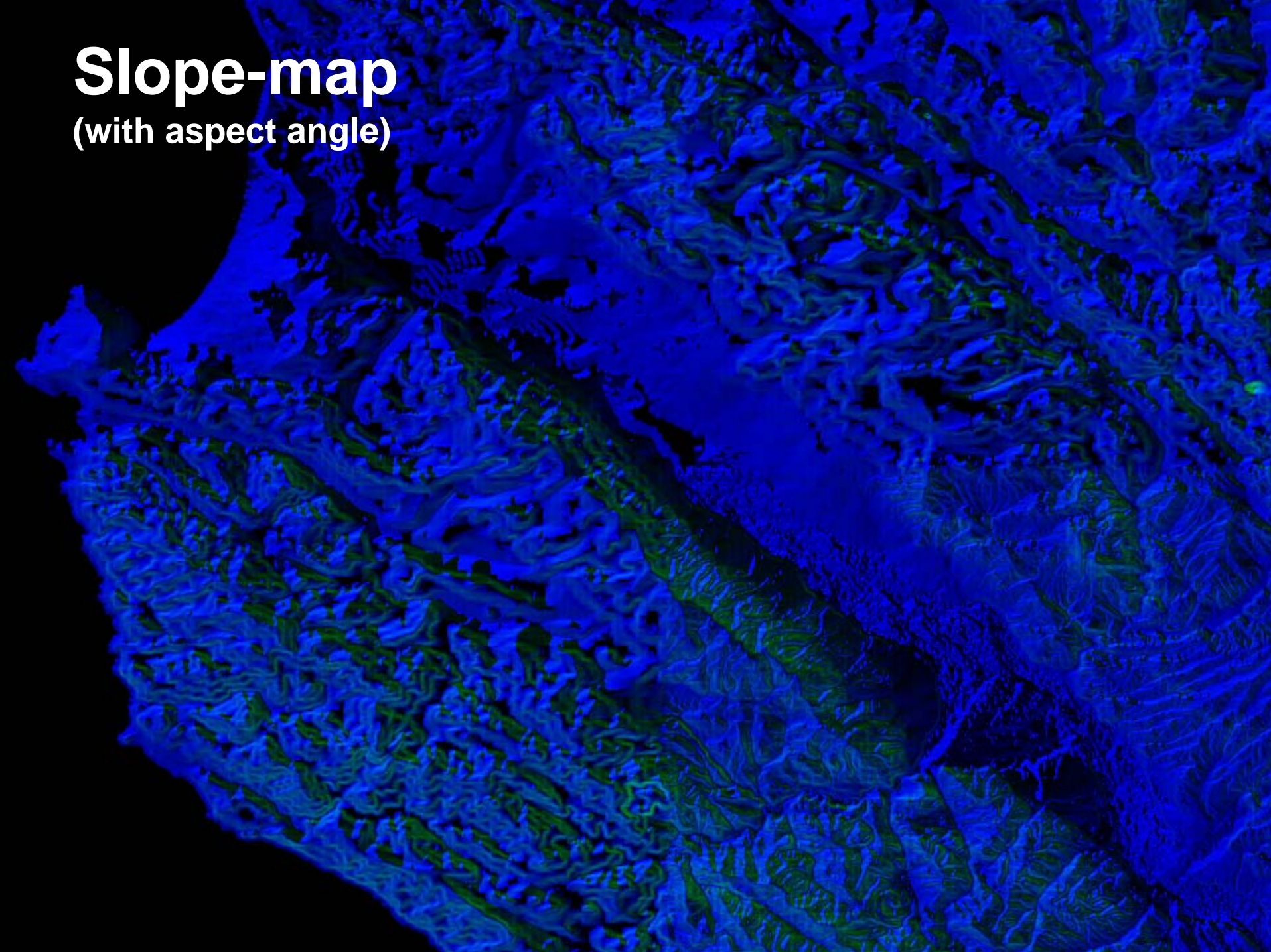


Slope-map

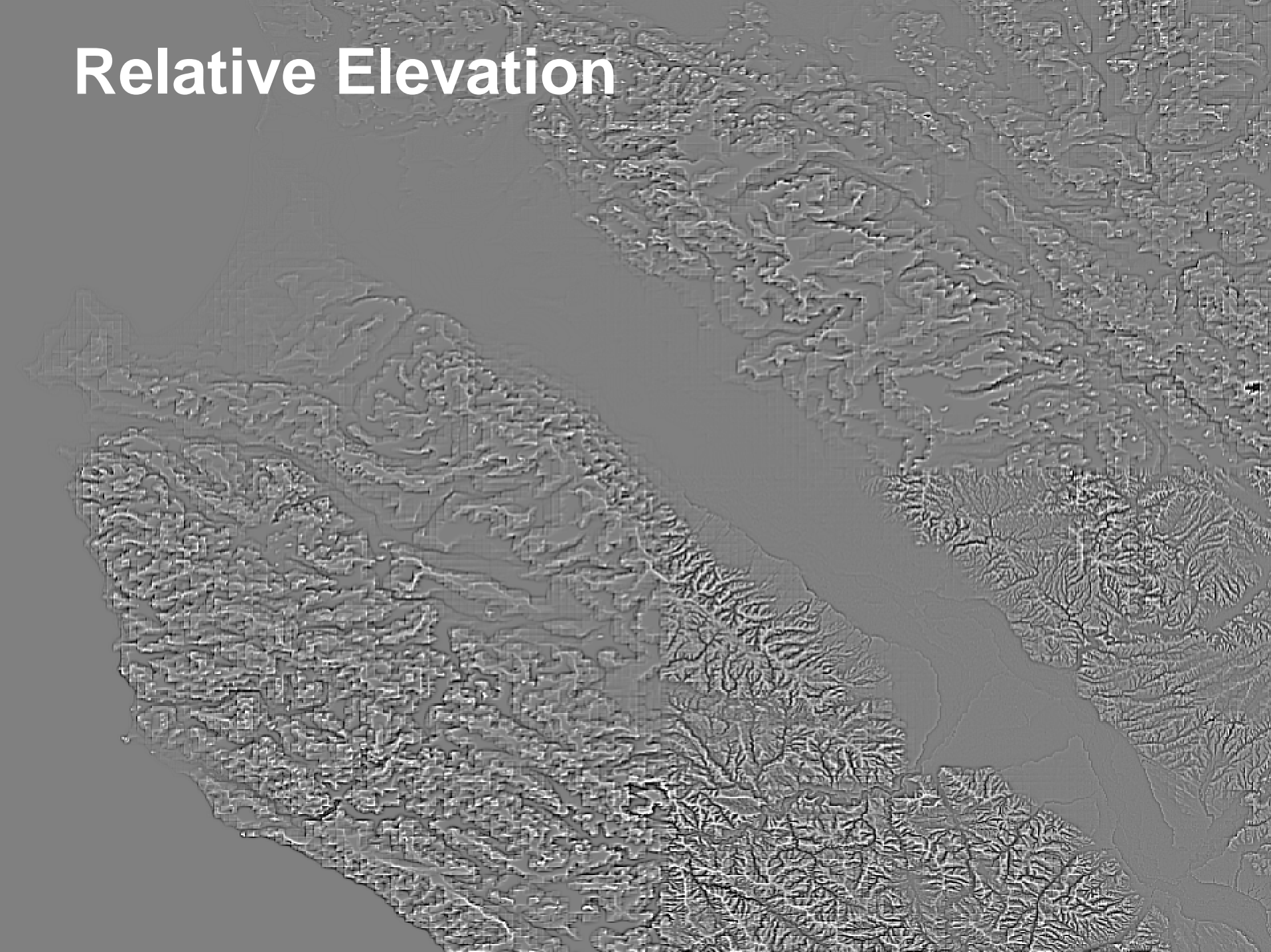


Slope-map

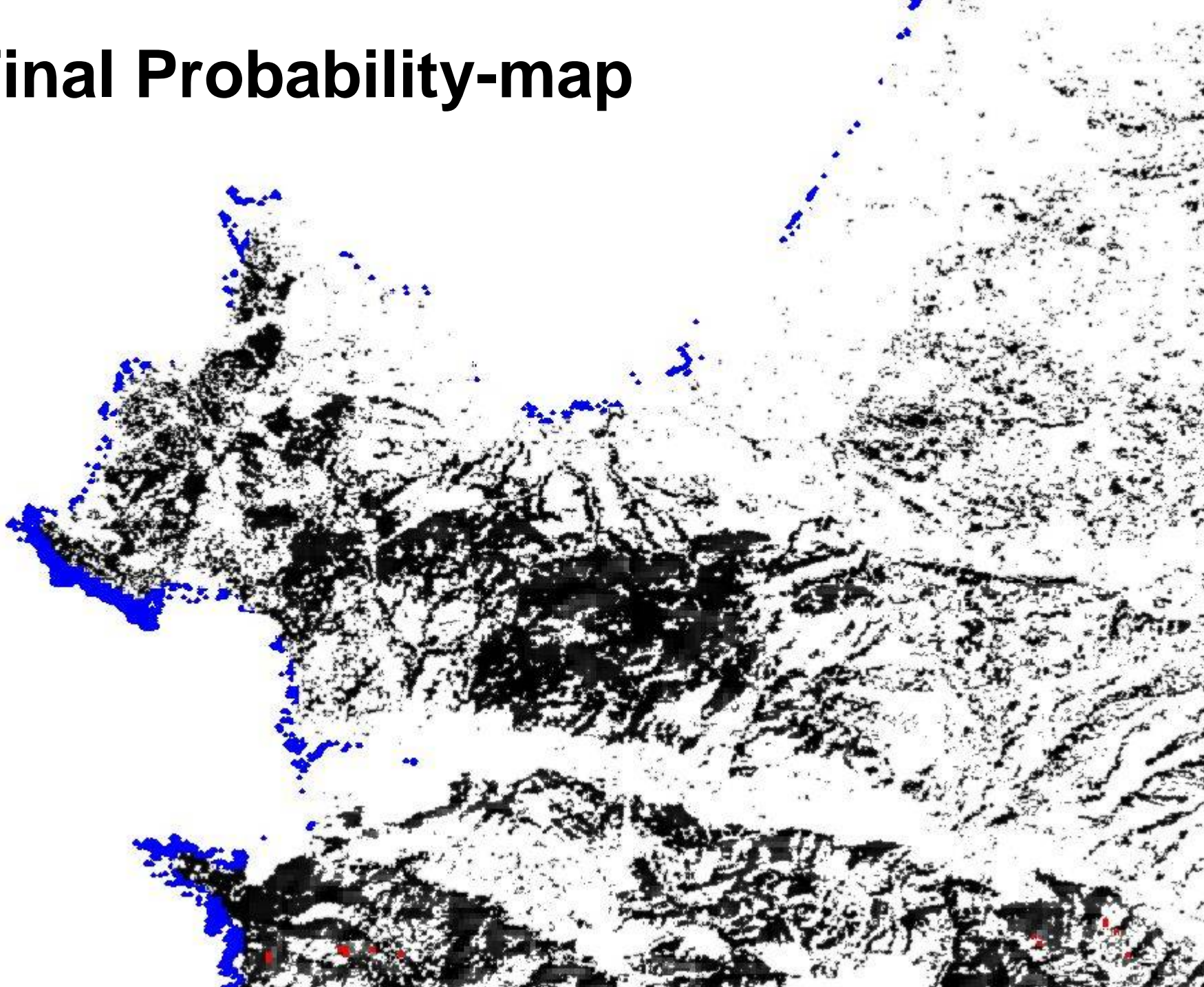
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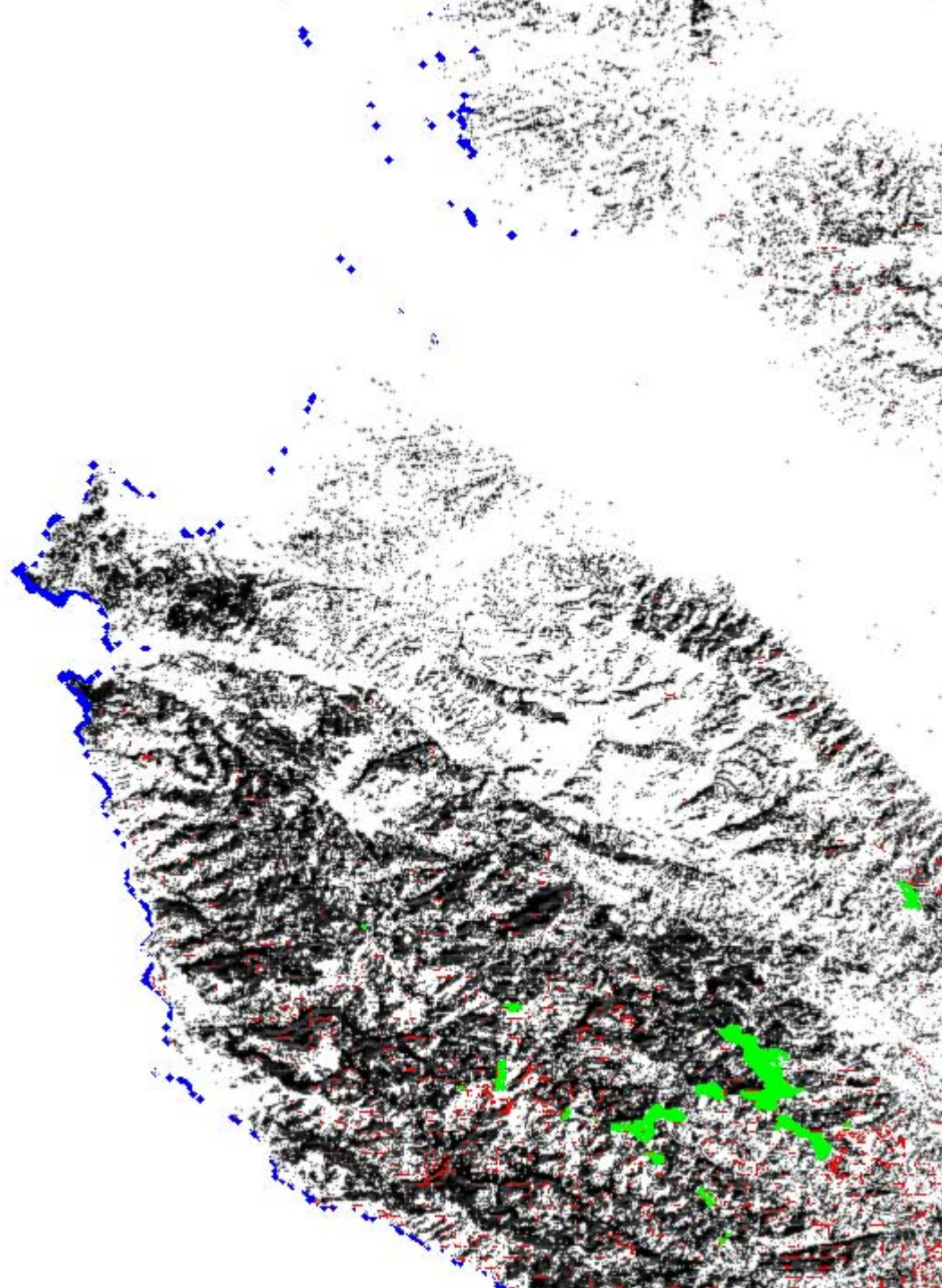


Relative Elevation



Final Probability-map

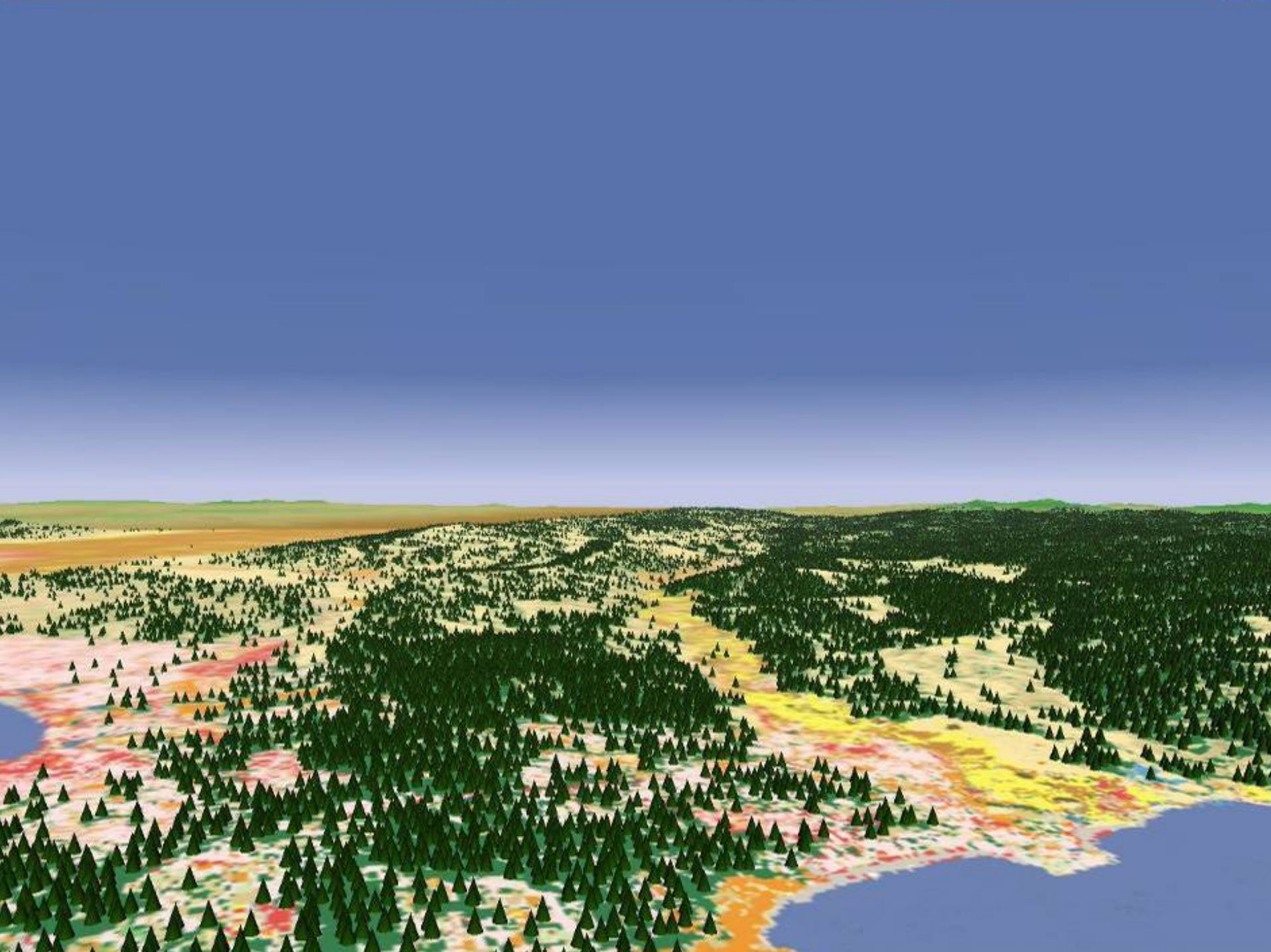


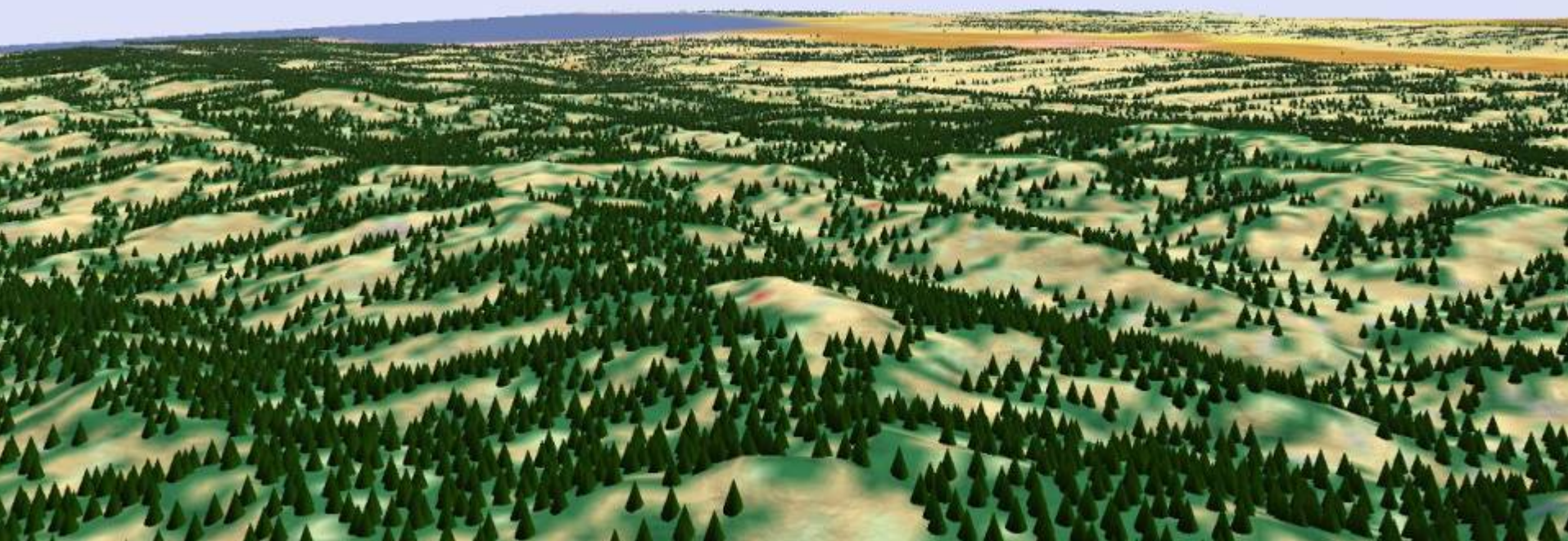


Blue – too low

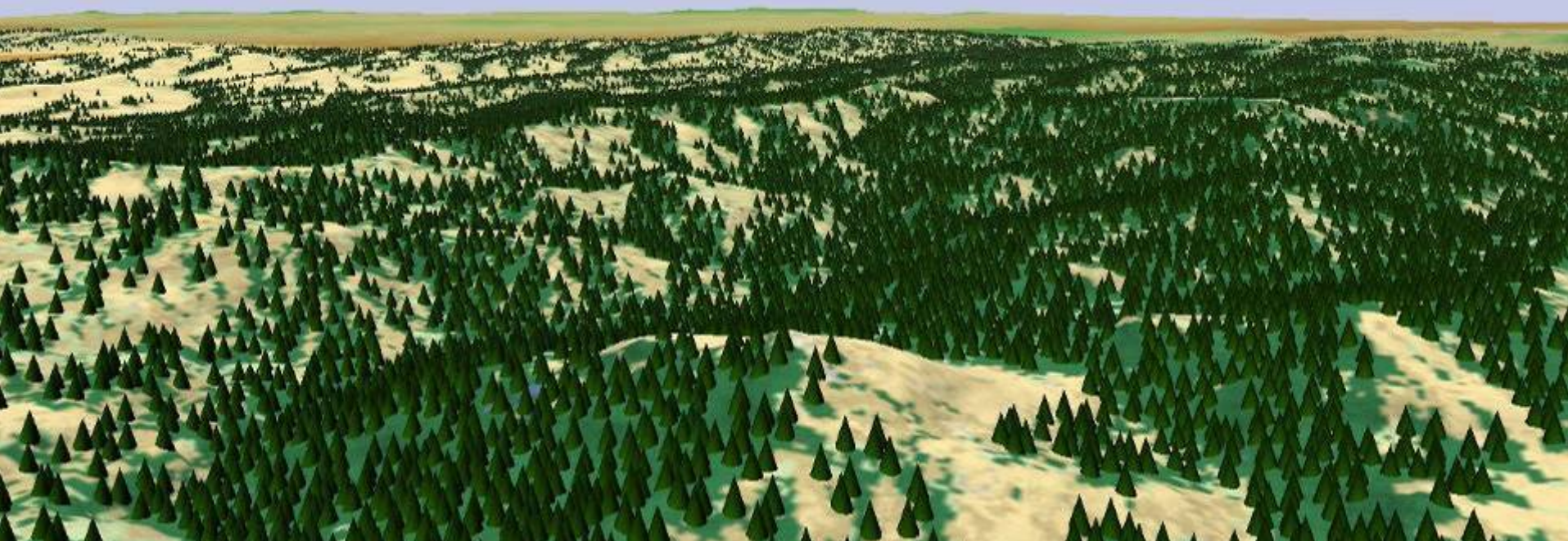
Green – too high

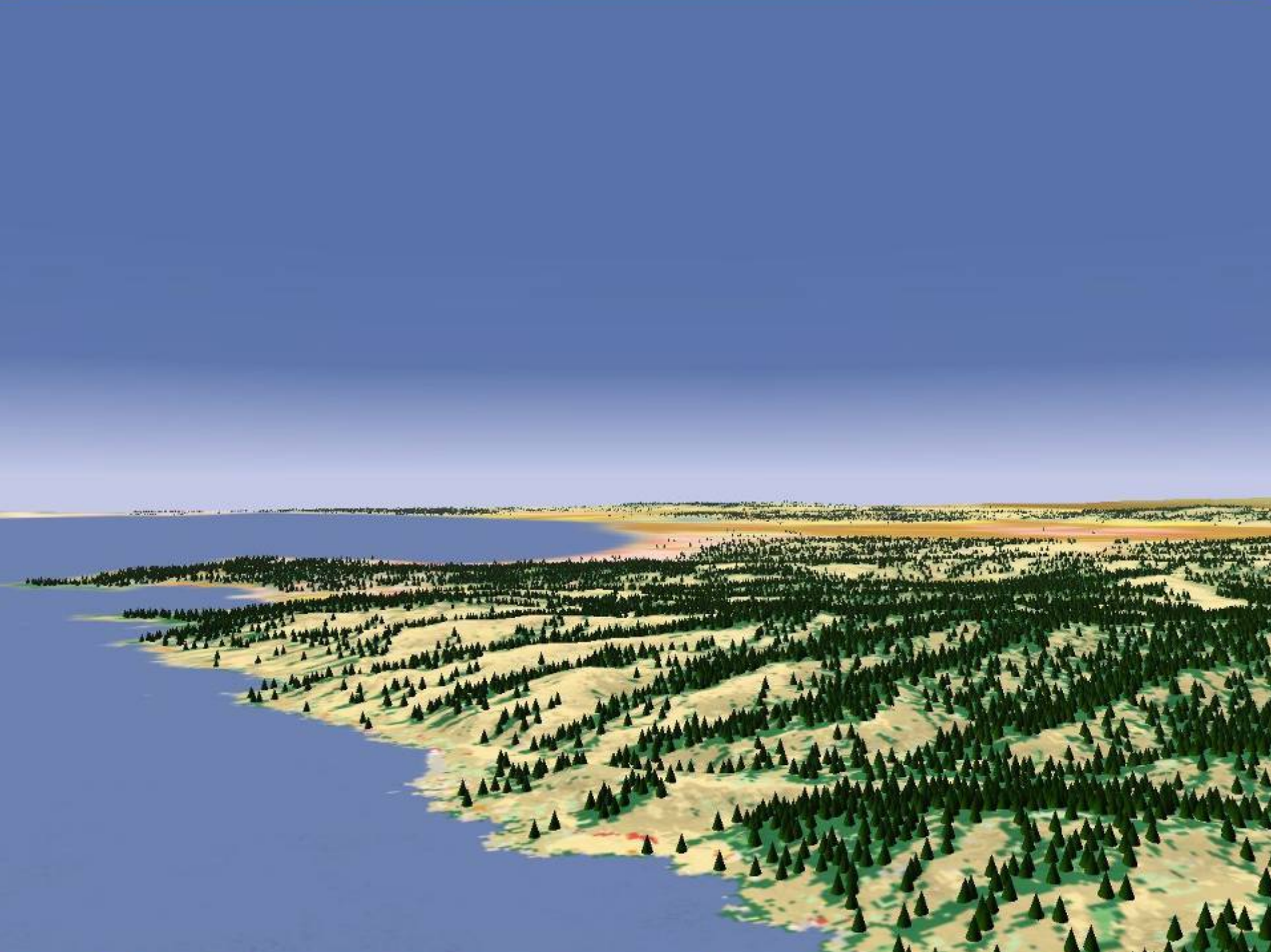
Red – too steep



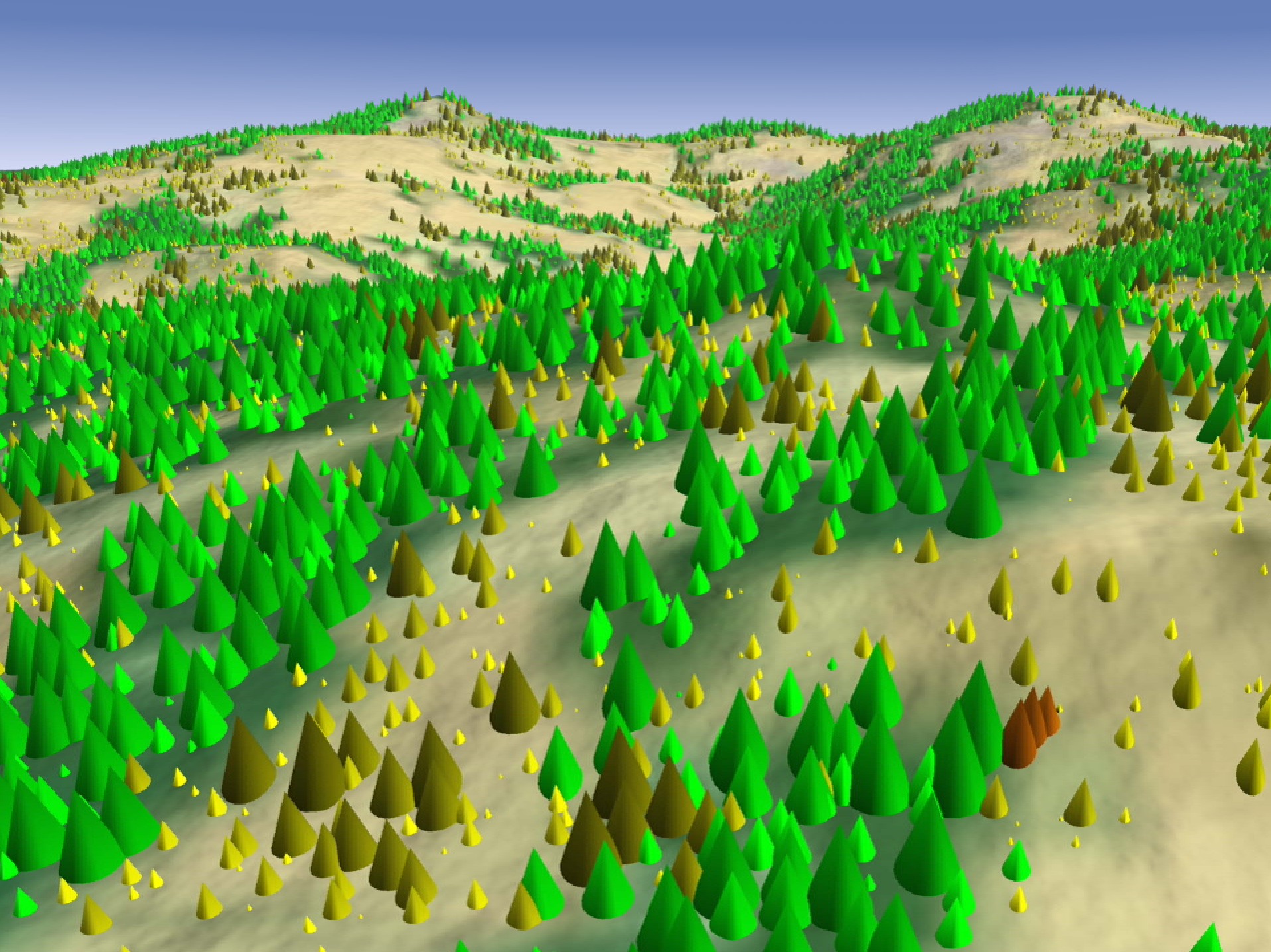


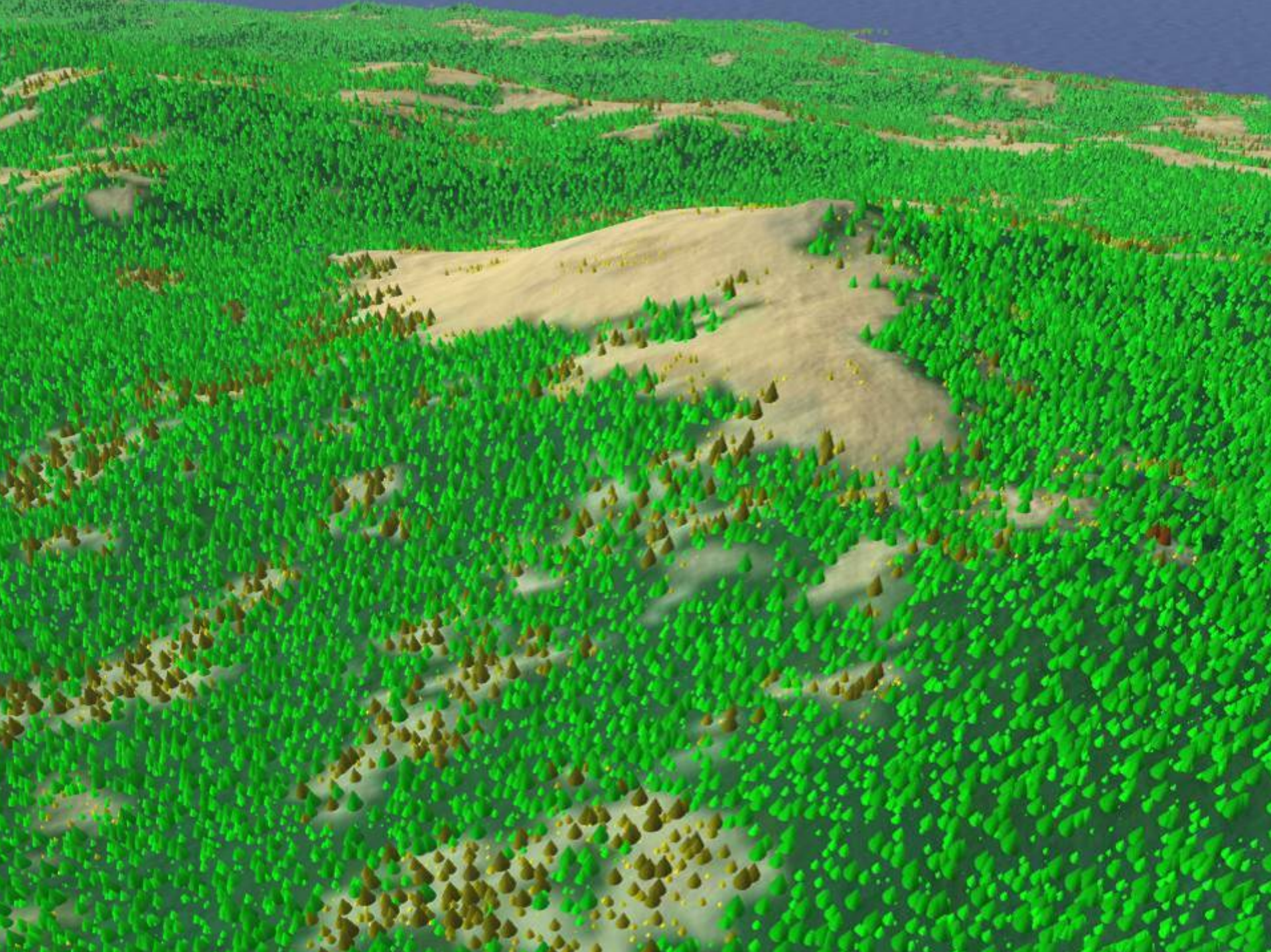


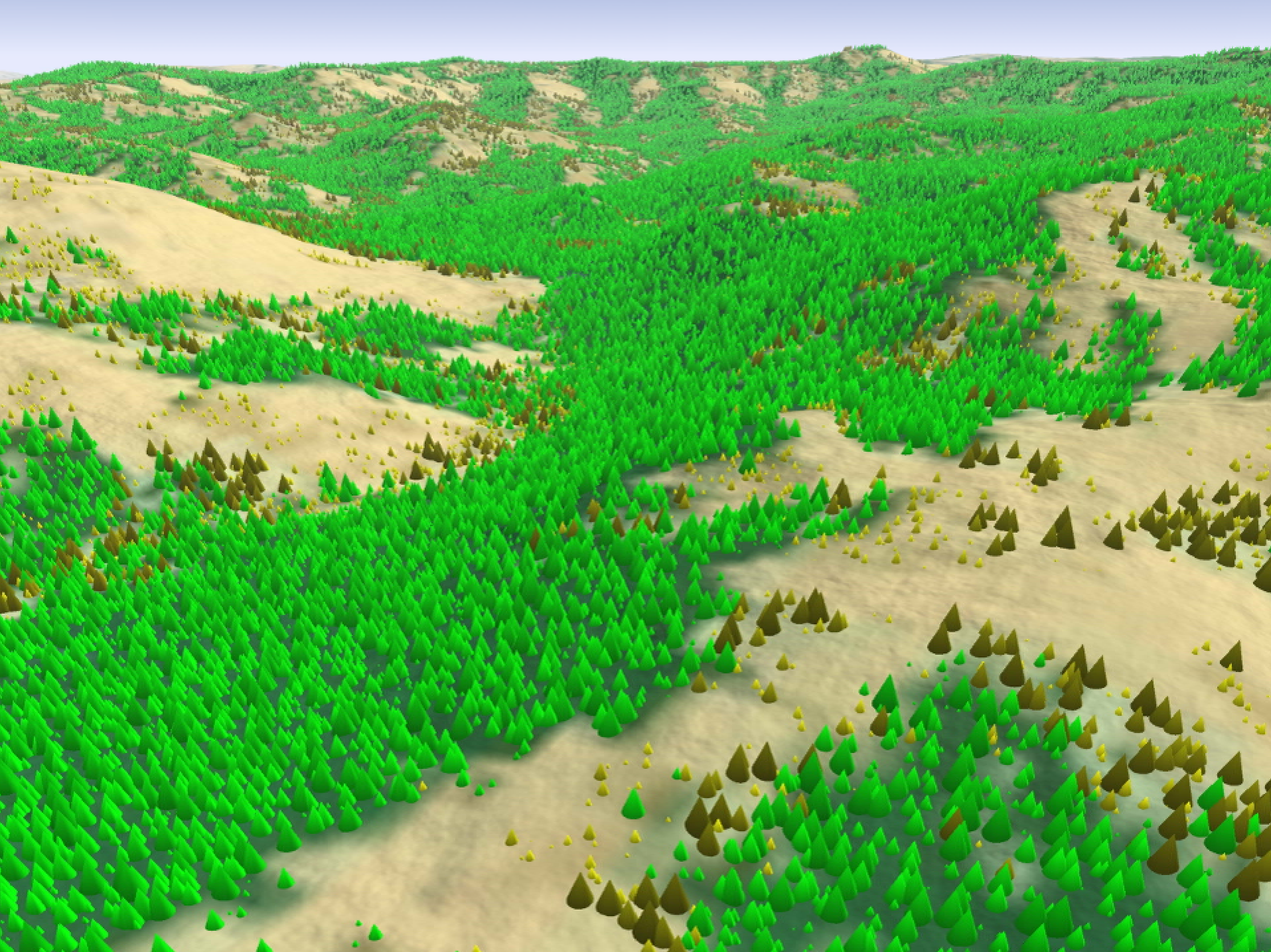


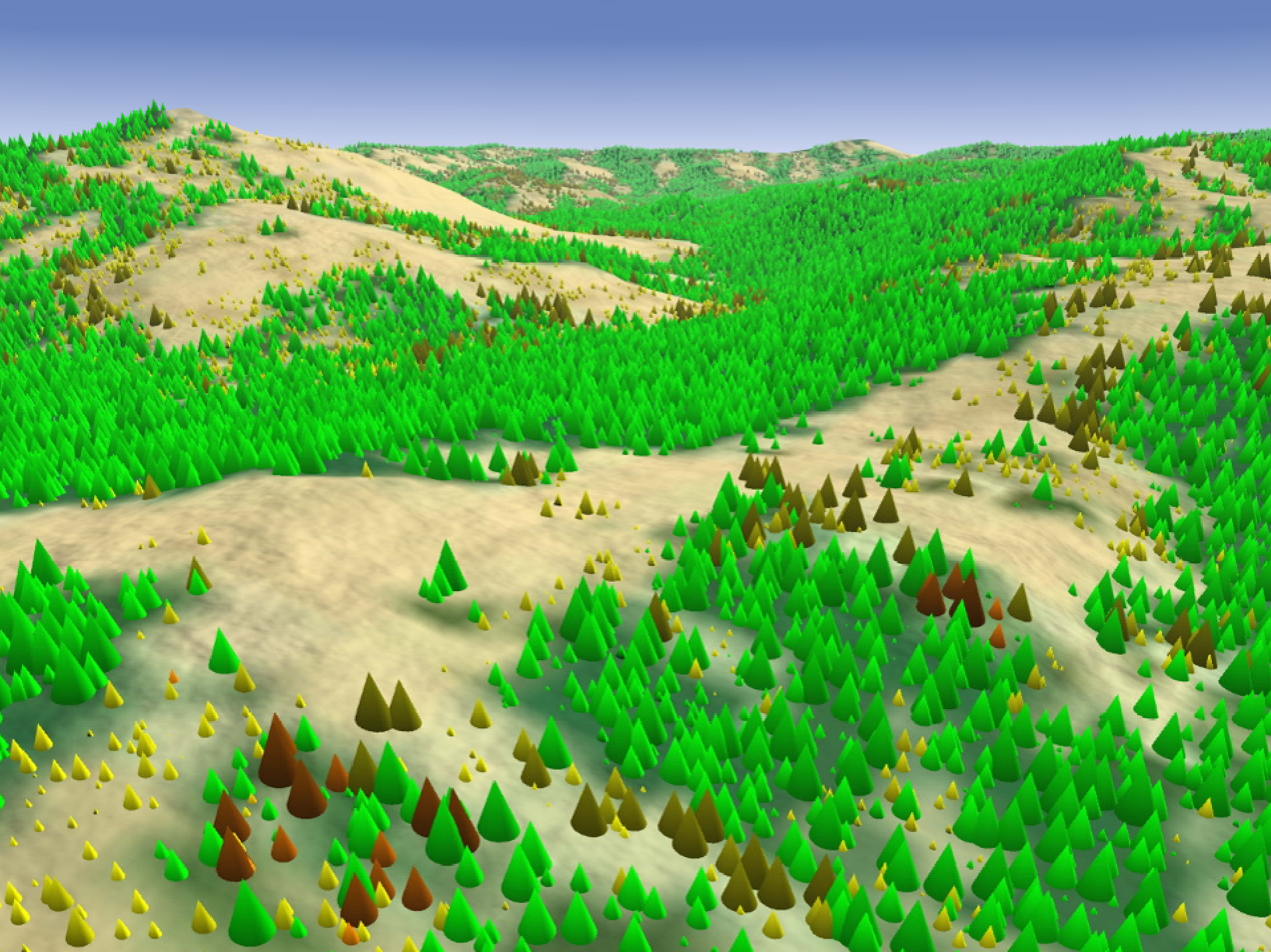


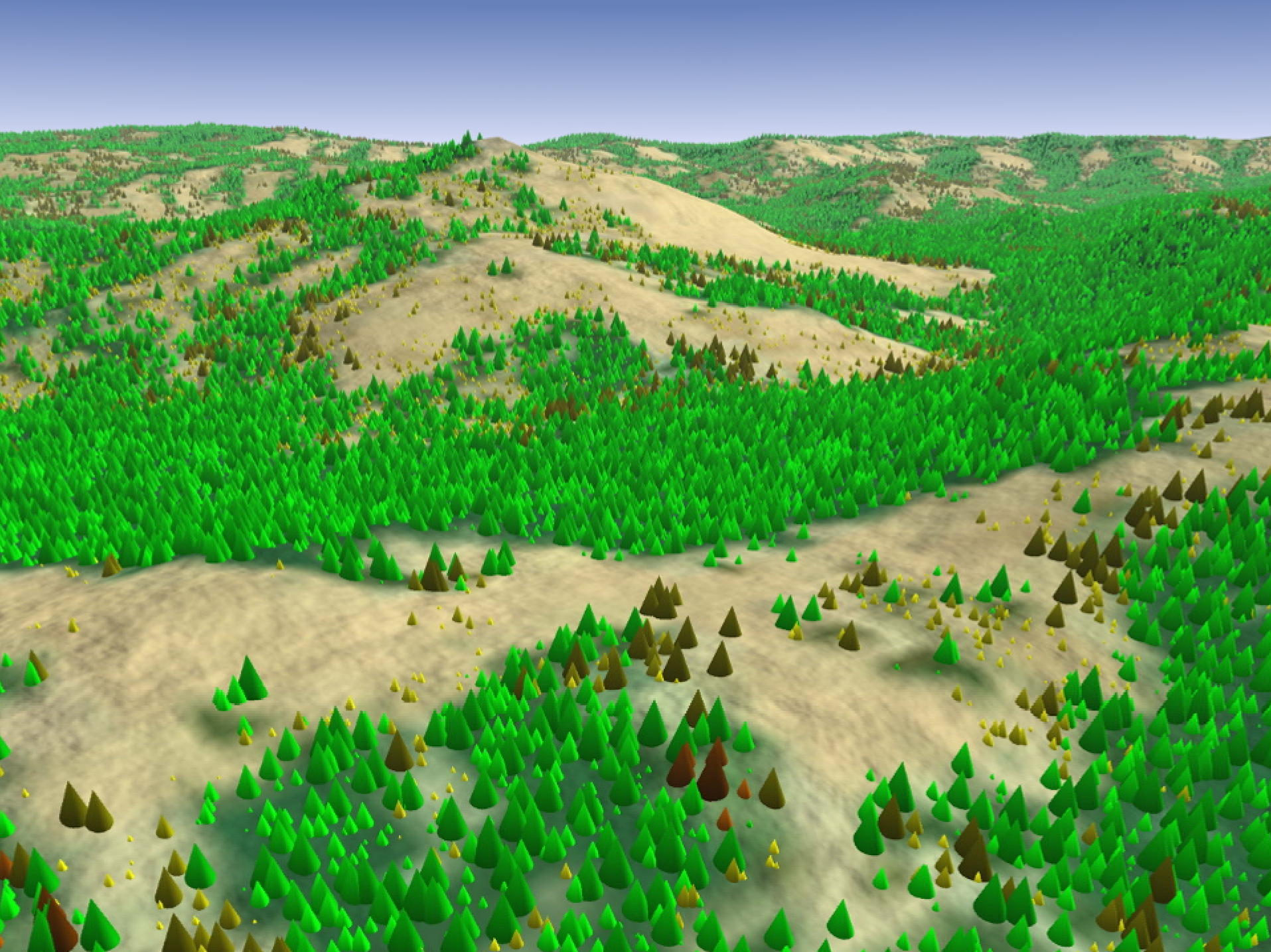


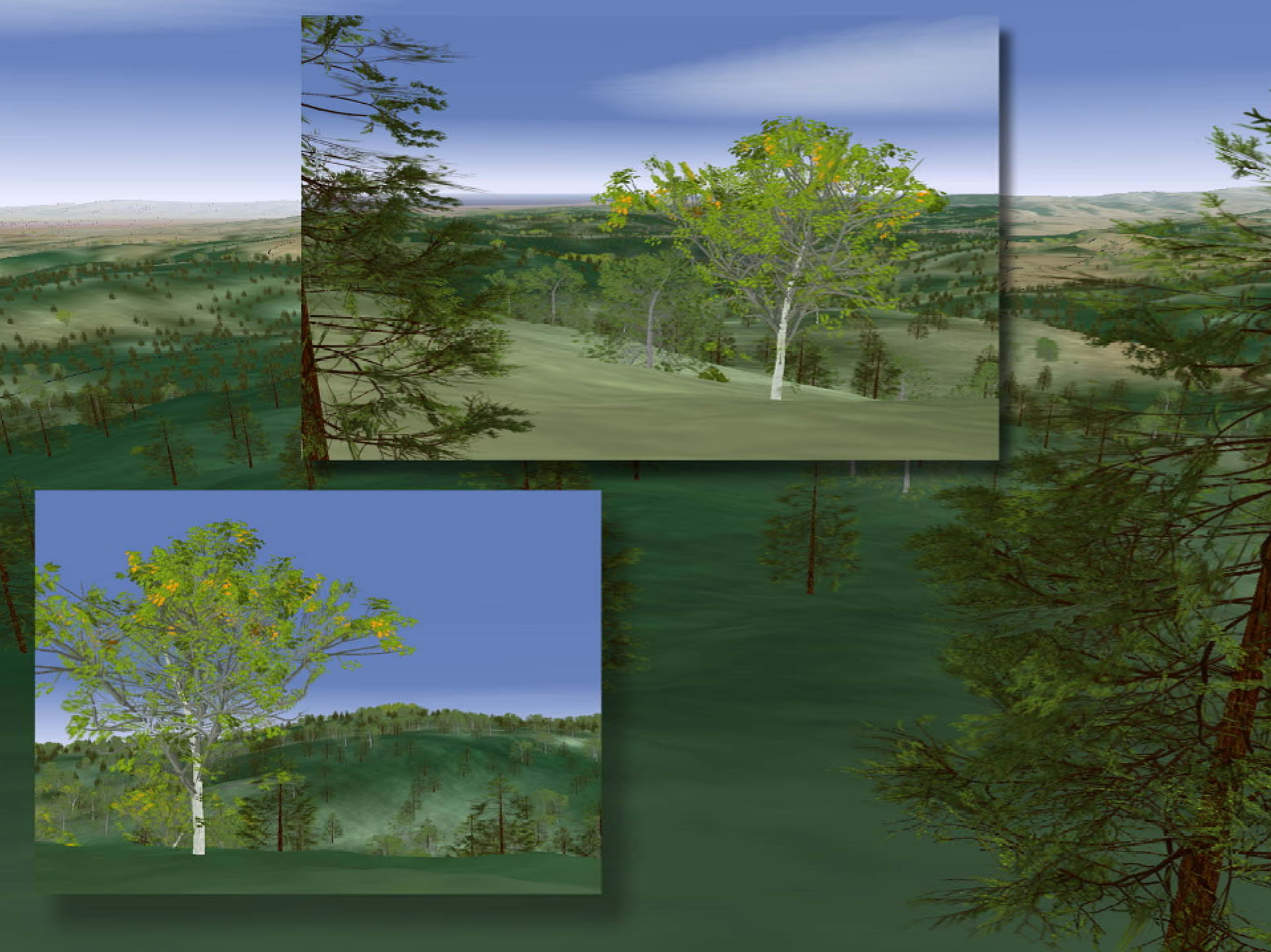


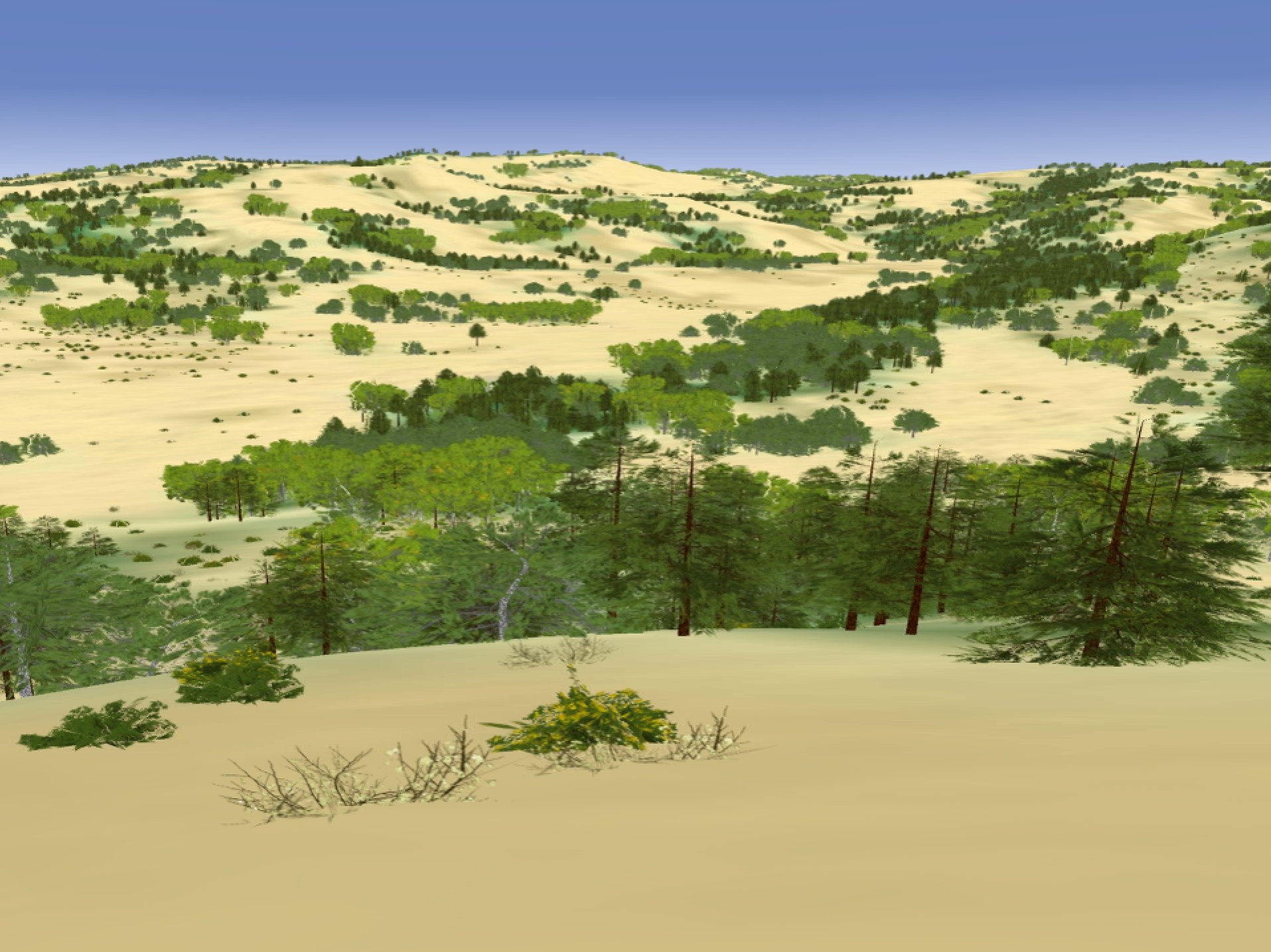


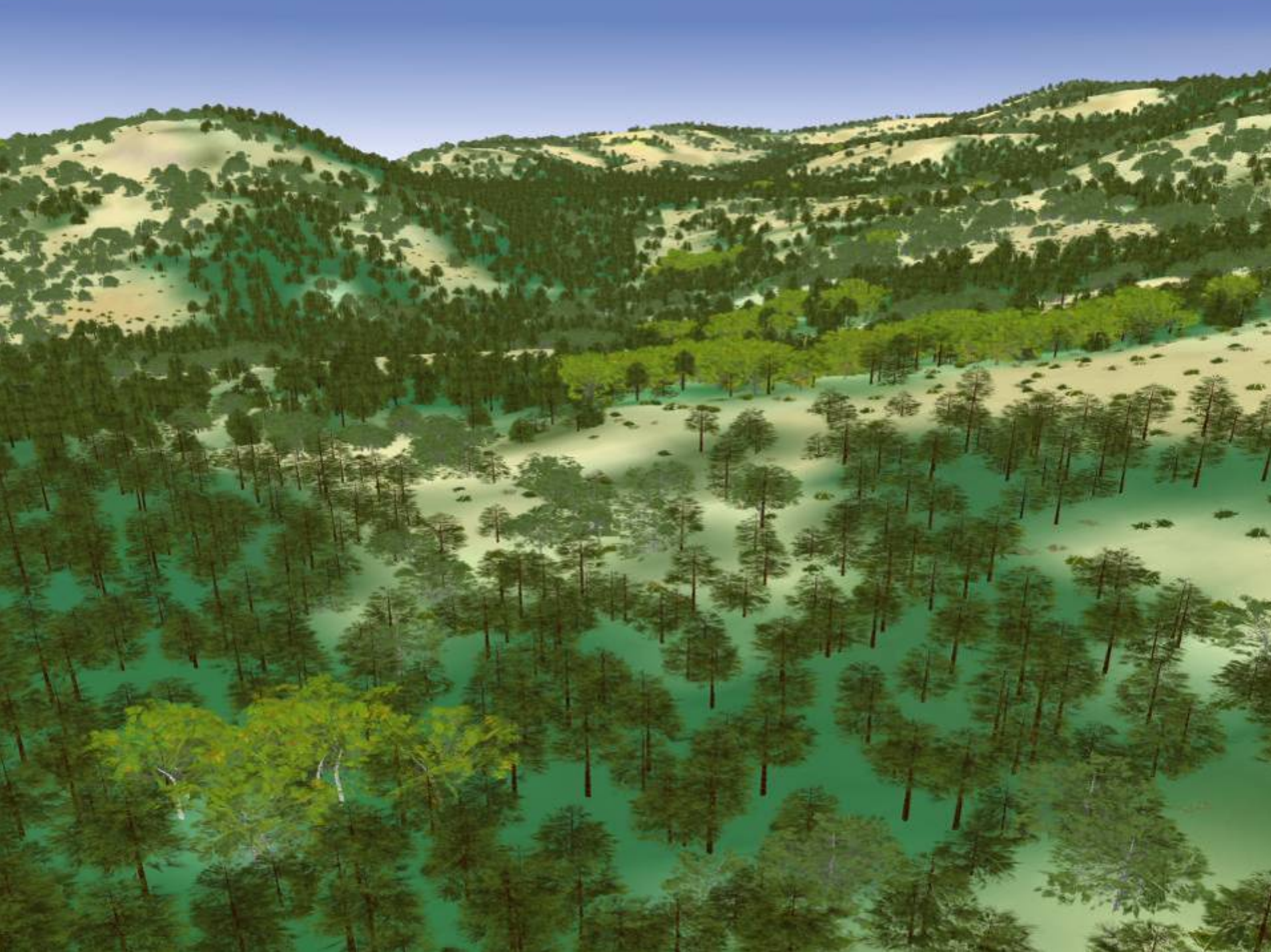


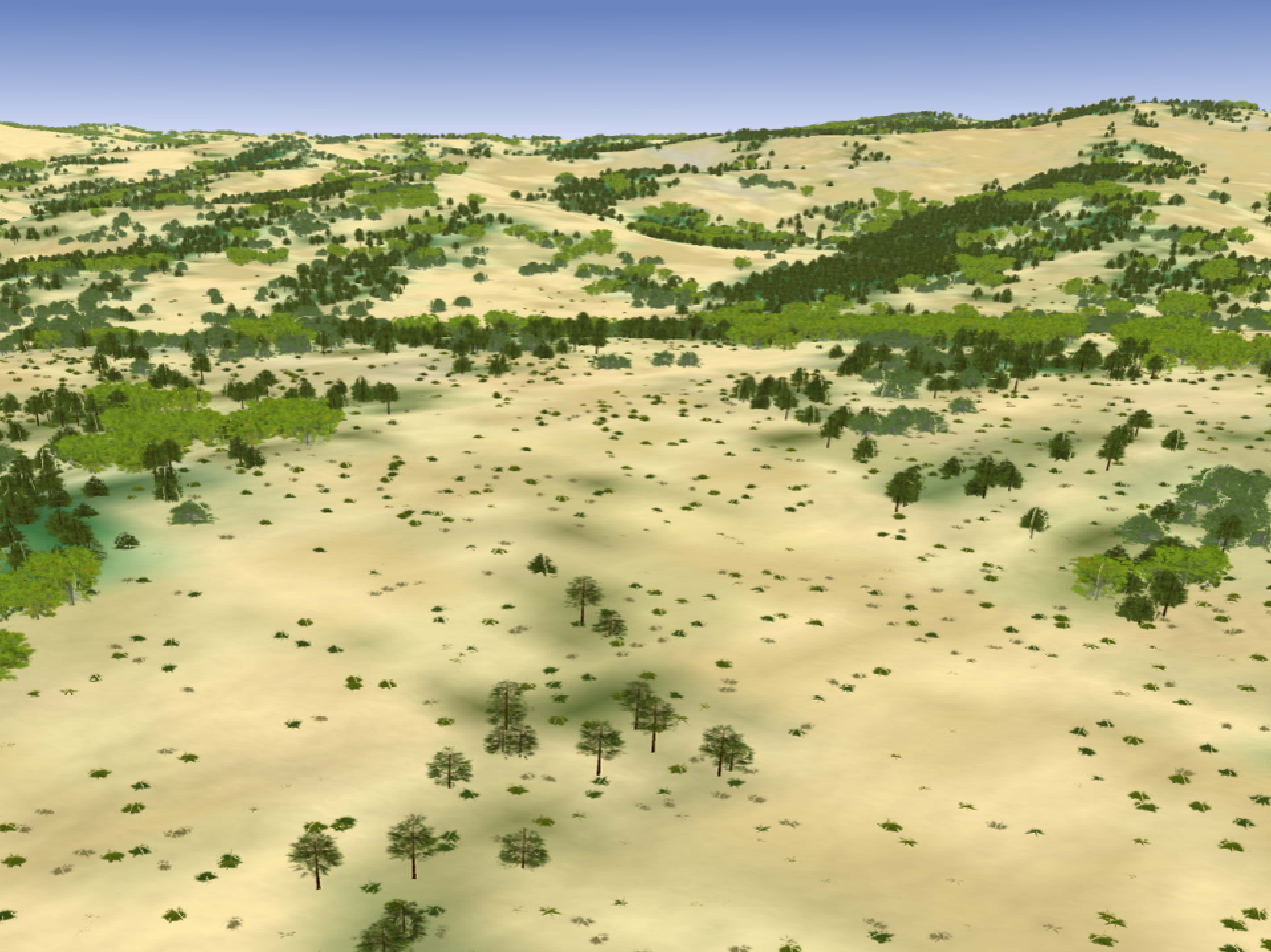


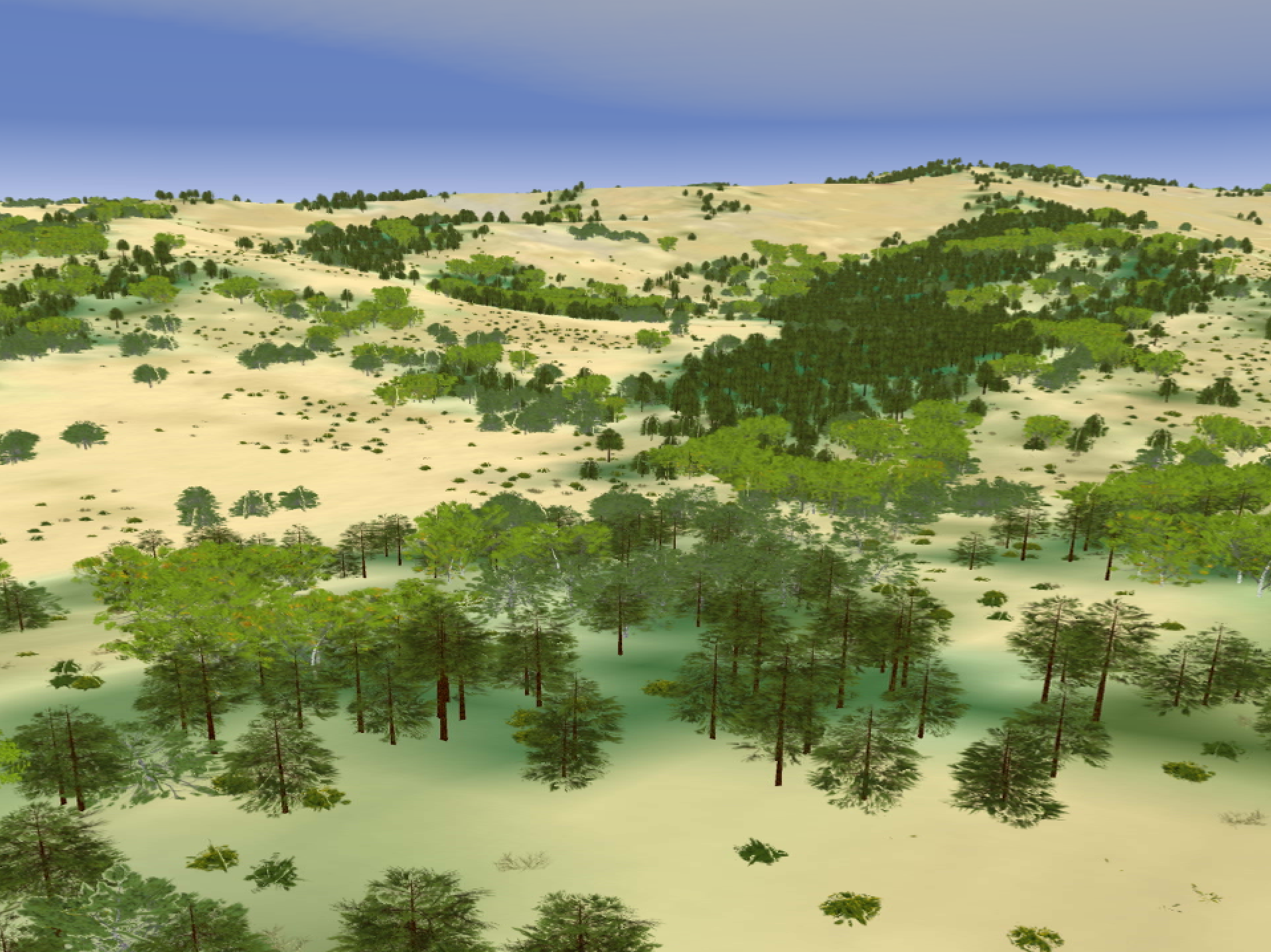


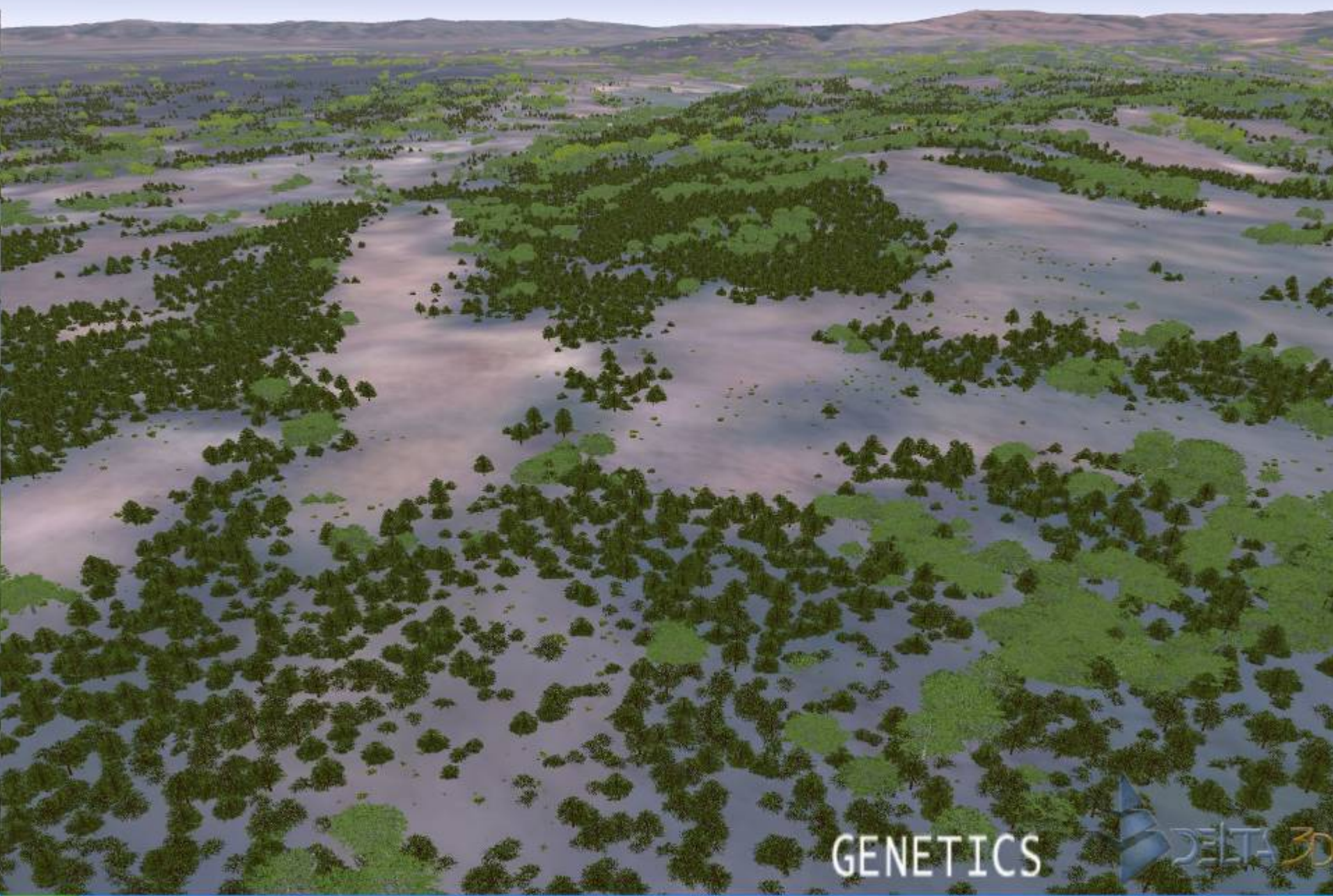






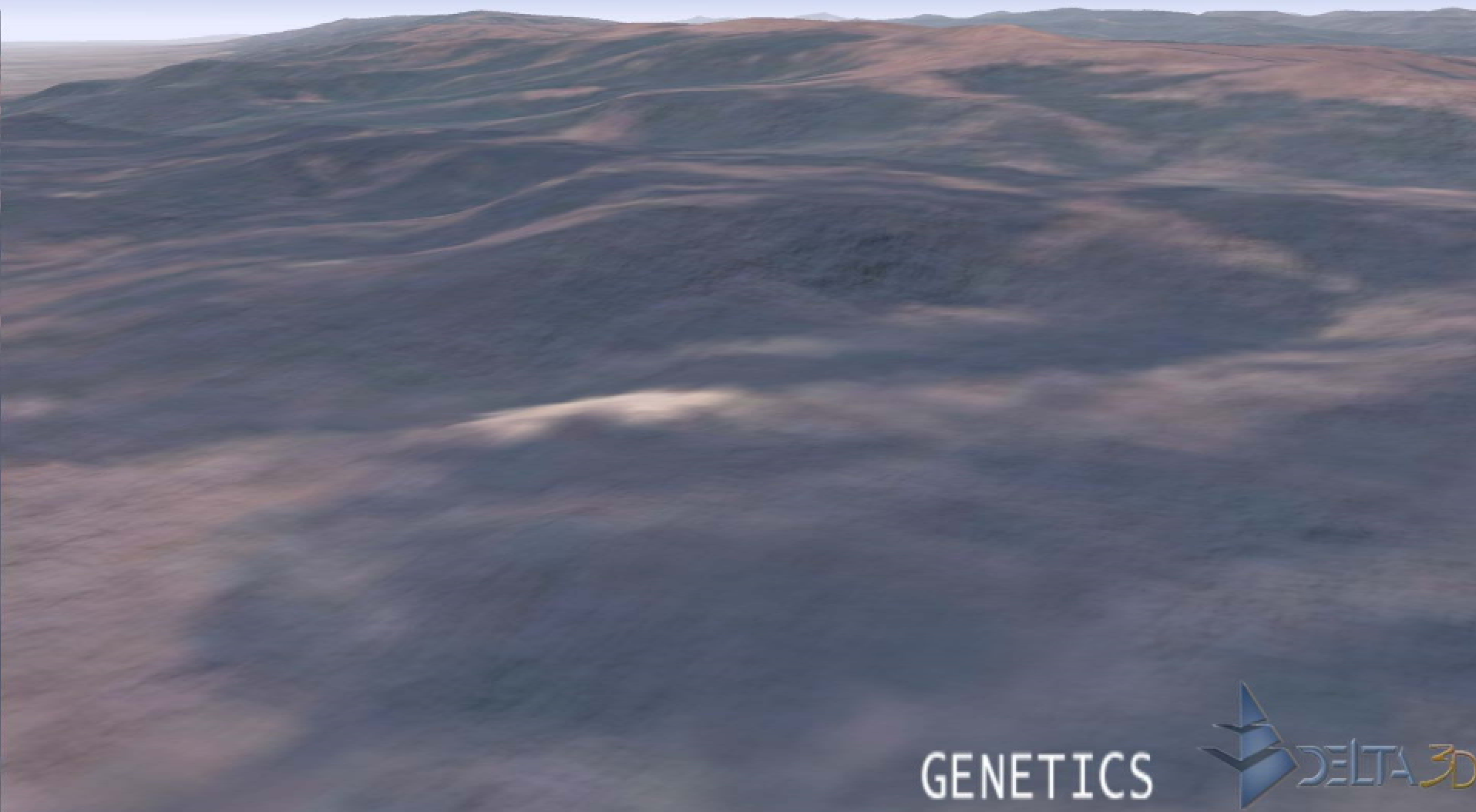






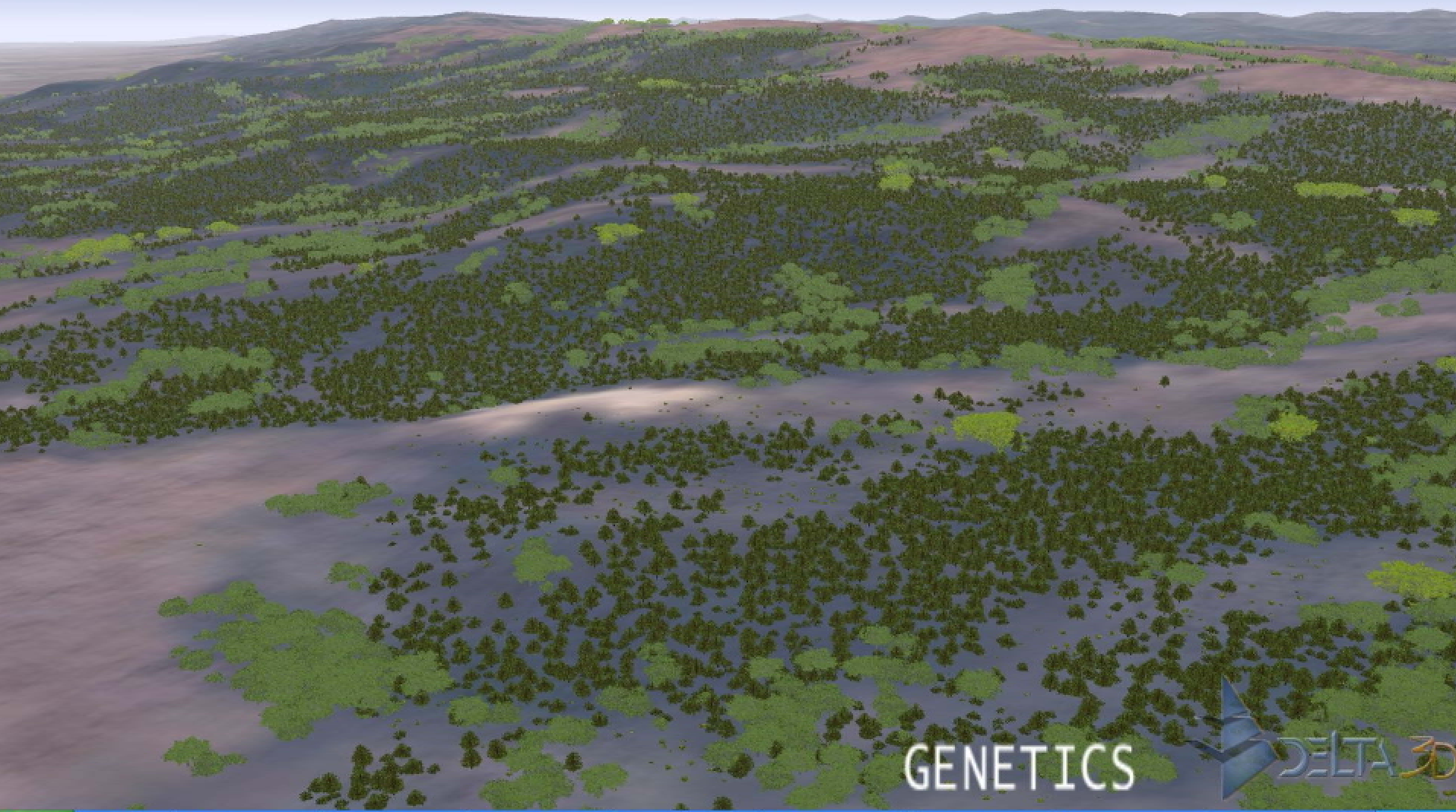
GENETICS





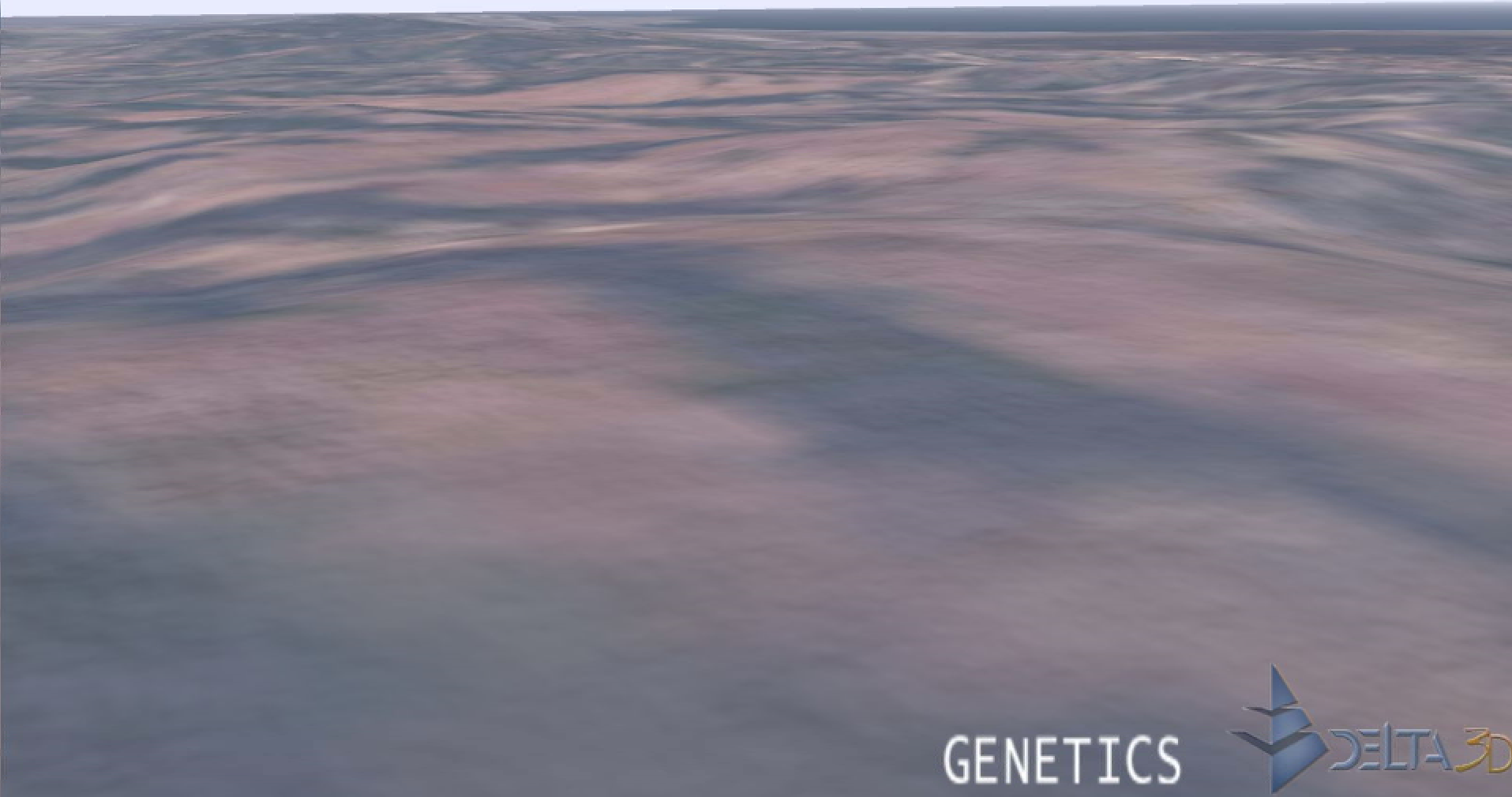
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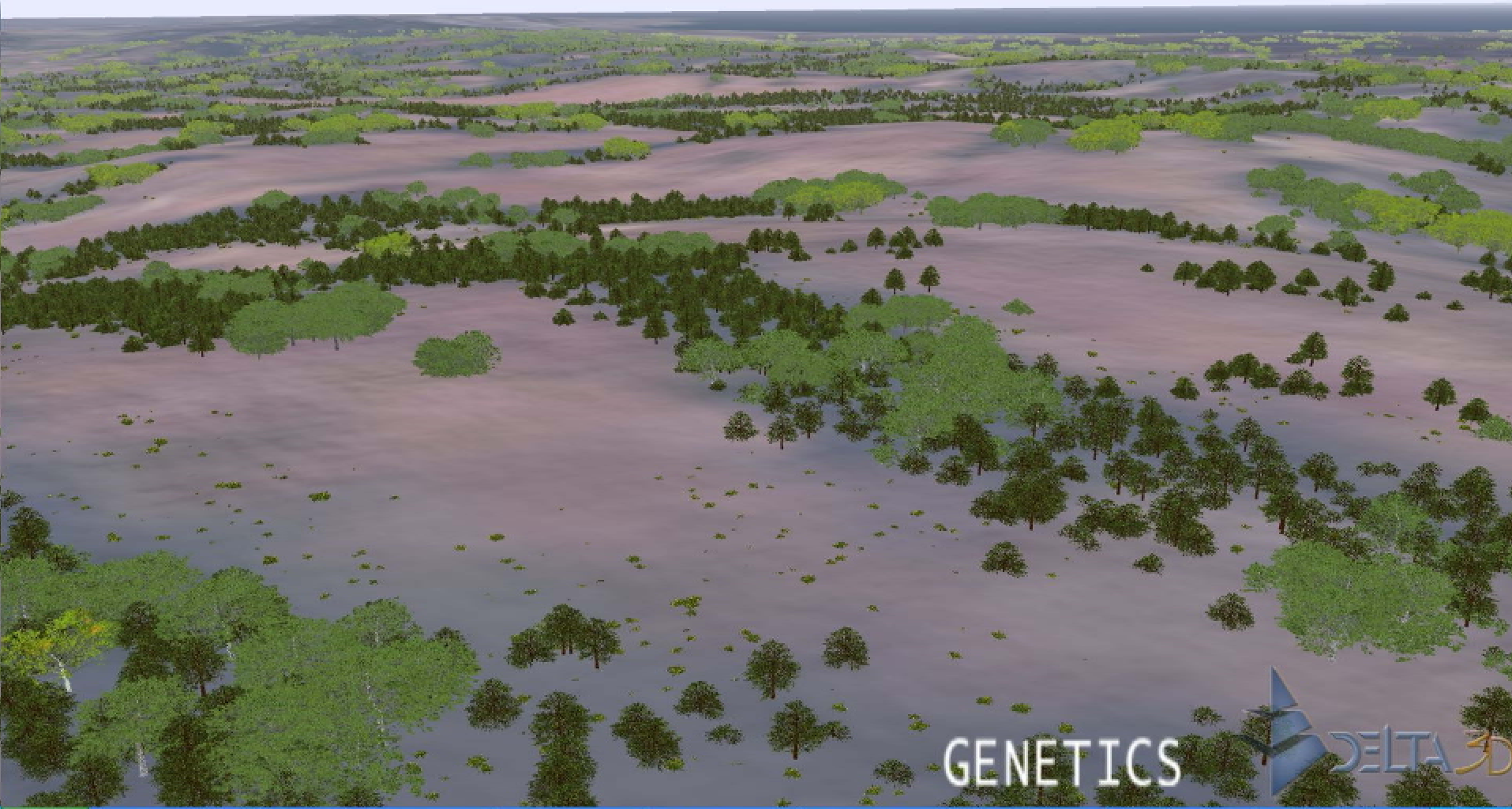
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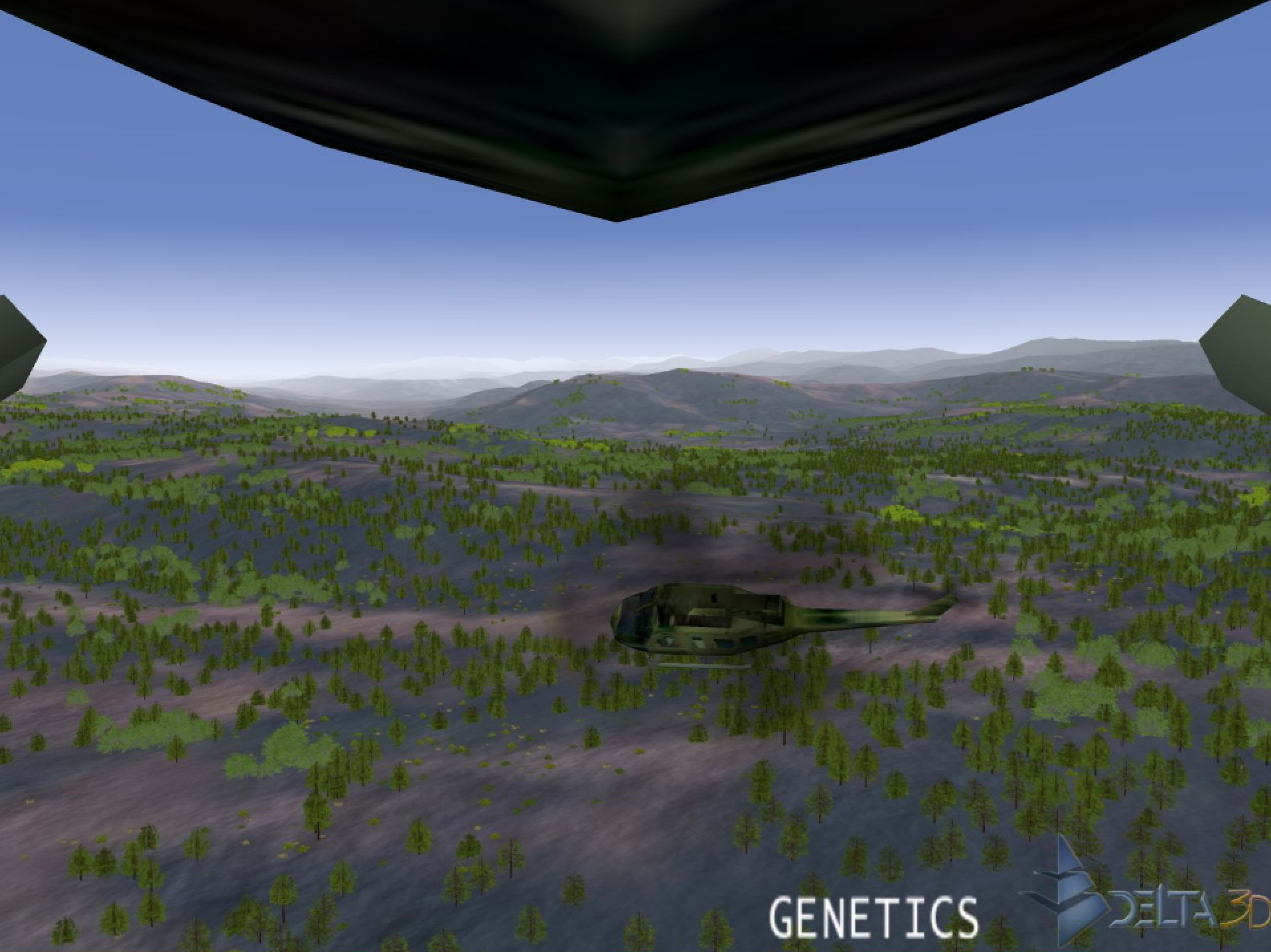
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GENETICS



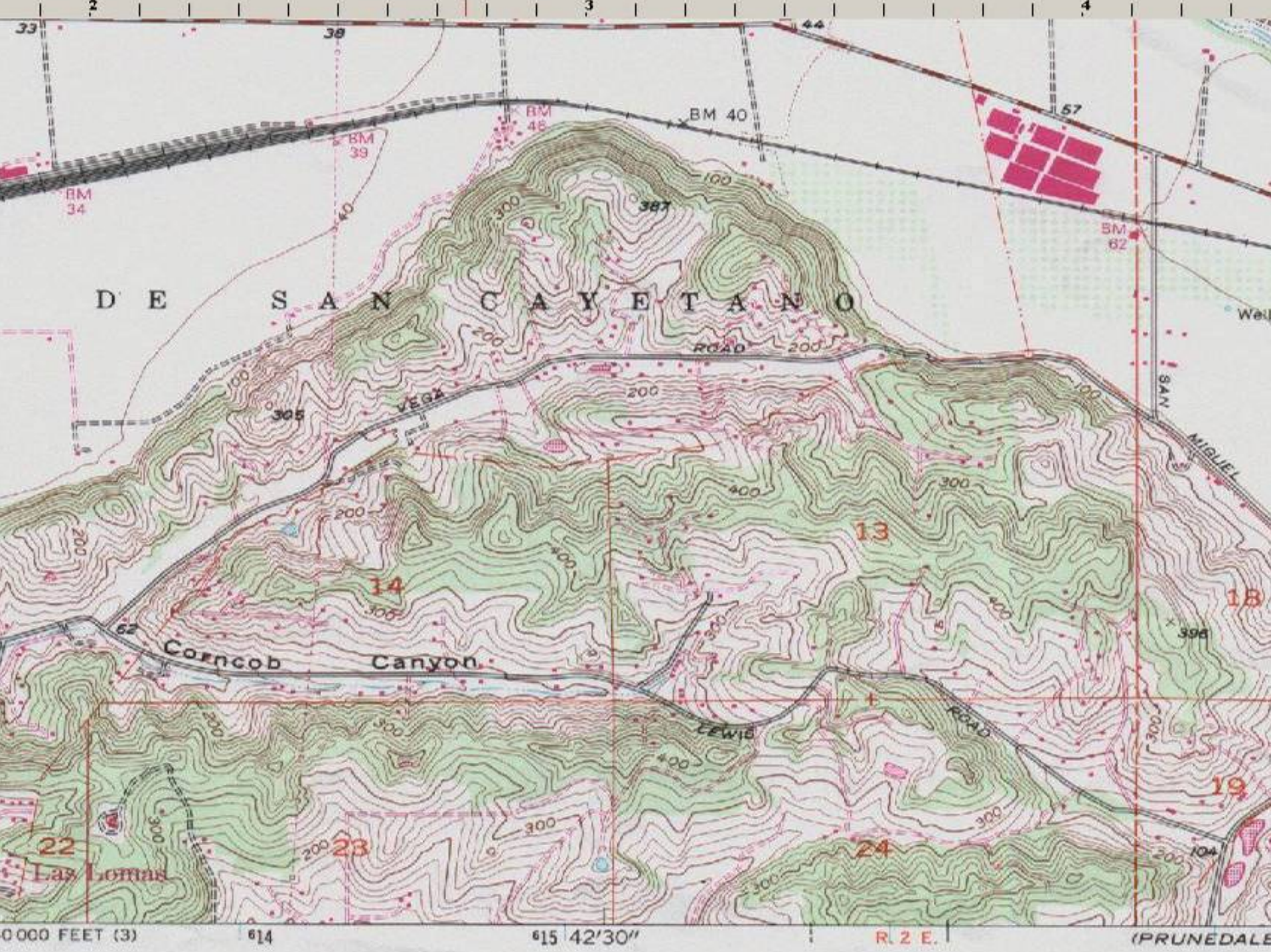


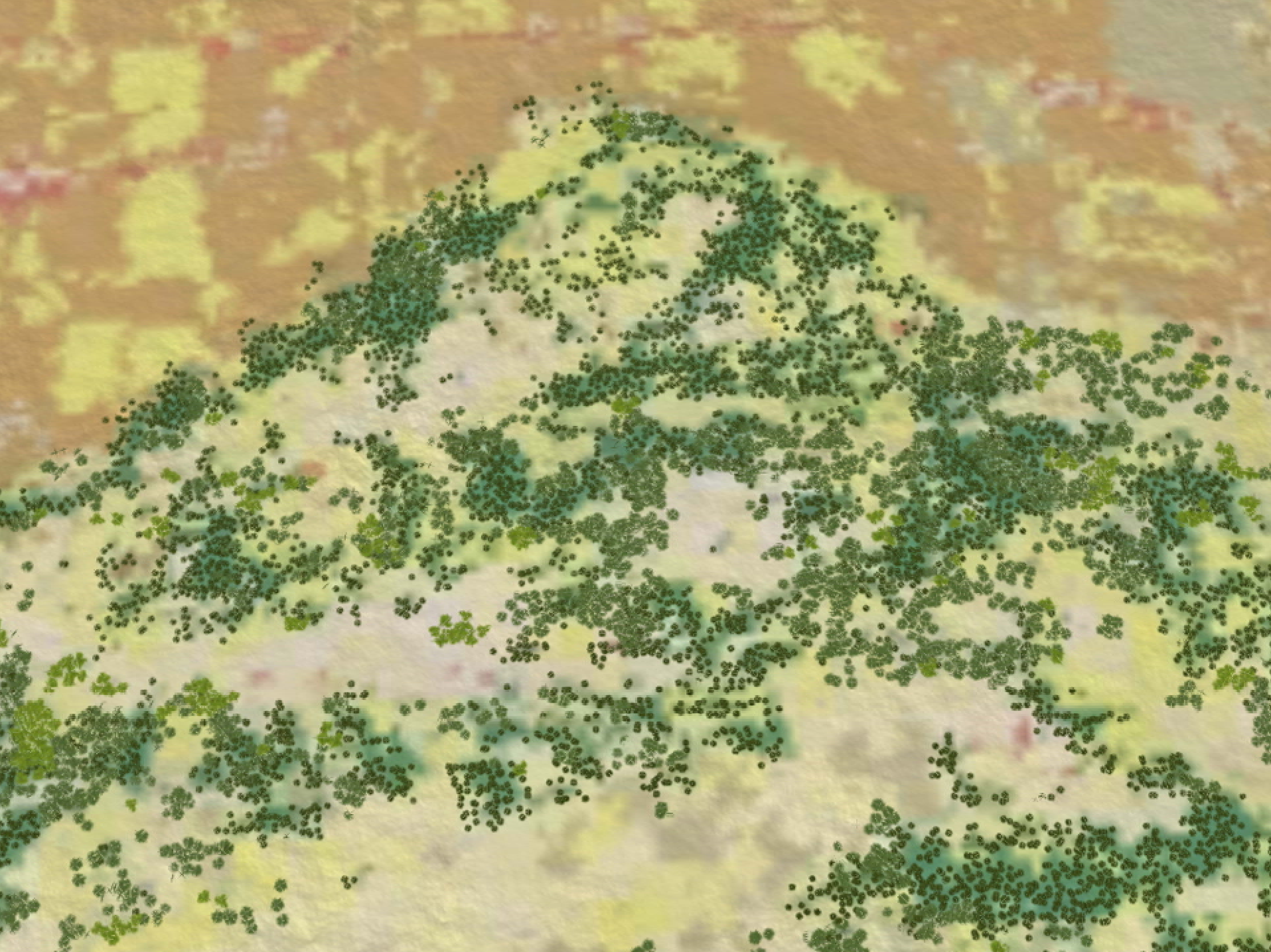
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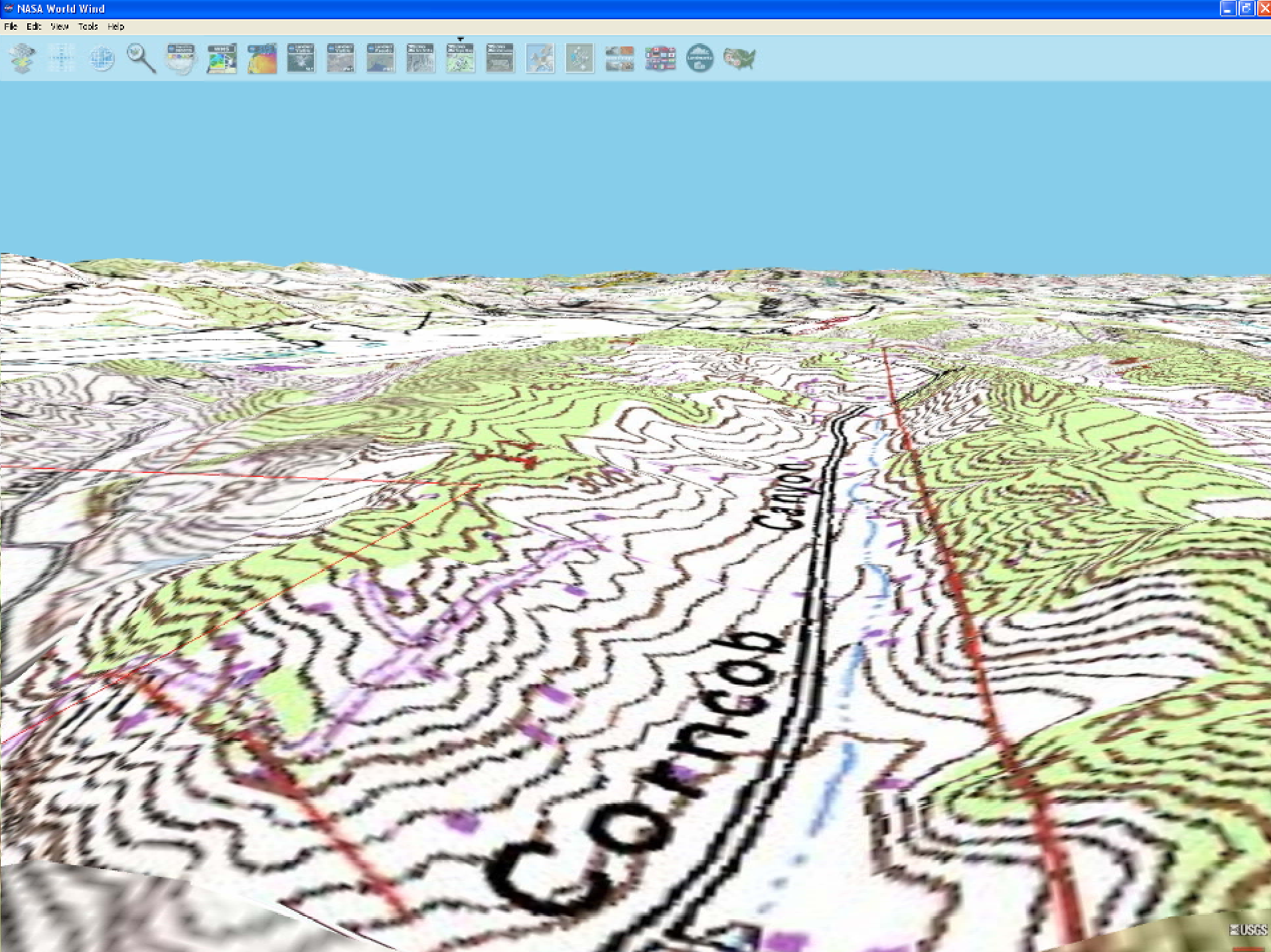


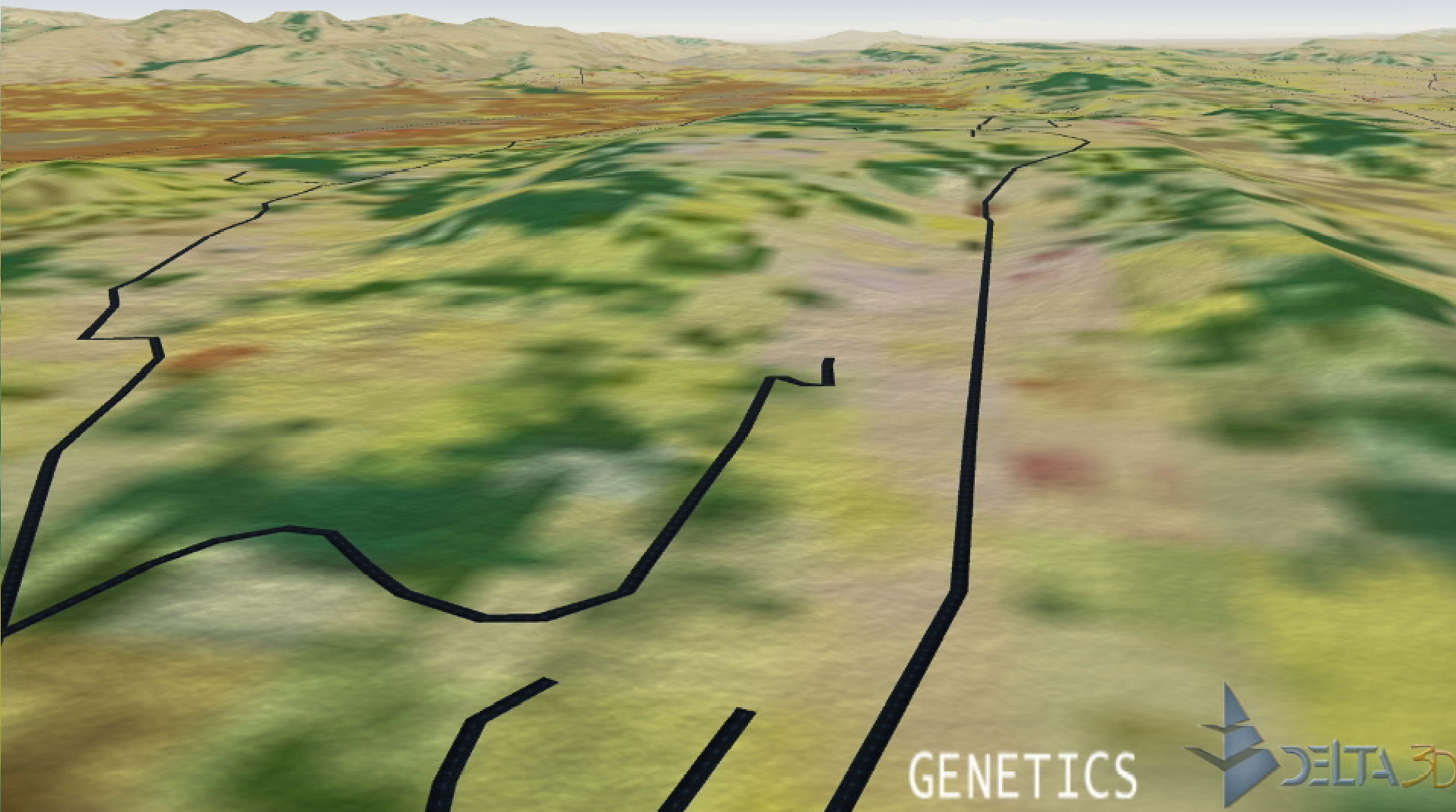


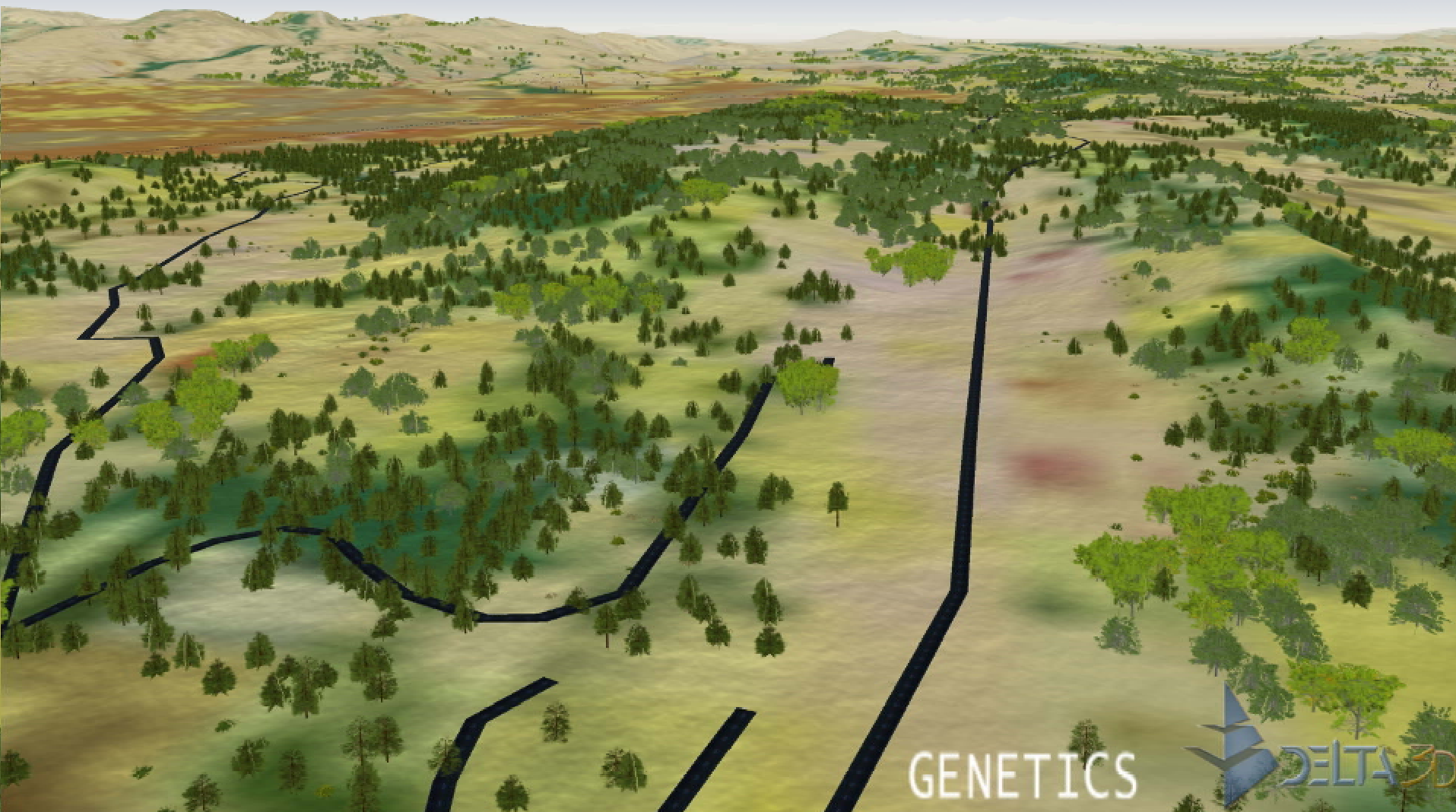














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Conclusions



- Can create a geocell's worth of vegetation in <2 min
 - ~2M objects within a 100km x 100km cell
 - Generated at run-time, on-the-fly, as needed
 - All players create the same terrain using same data/params
- Improvements over typical terrain databases
 - Variable vegetation density; Overlapping vegetation types
 - No wasted artist time placing objects
 - Terrain object placement responsive to its environment
 - No playboxes
- Good enough for training (?)
 - Harder to spot targets
 - Range and distance easier to judge (esp. against poor imagery)
 - Makes terrain “come to life”

Next steps



- Refine LCC topographical regimes
- Add NLCD 2001 forest canopy & imperviousness datasets (limited coverage so far)
- Improve scene optimization and render speeds
- Texture splatting for ground surface
- Measure the effect on tactical training(!)

Generating Enhanced Natural Environments & Terrain for Interactive Combat Simulations (GENETICS)



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